APPENDIX FOUR d

A REVIEW OF THE METHODOLOGICAL APPROACH USED TO DEVELOP AN EPS FOR THE MANAGEMENT OF LONDON'S MUNICIPAL WASTE

Greater London Authority

Municipal Waste EPS Review

A Review of the Methodological Approach Used to Develop an Emissions Performance Standard for the Management of London's Municipal Waste

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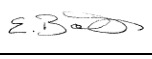
		Signature			
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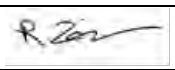
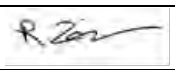
		Signature			
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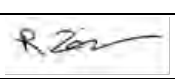
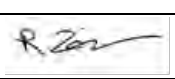
		Signature			

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Executive Summary

Introduction

Ove Arup & Partners Ltd (Arup) has been commissioned by the Greater London Authority (GLA) to review the approach used to develop a carbon dioxide equivalent emissions performance standard (CO_2eq EPS) for the management of London's municipal waste (Mayor's EPS).[1]

The purpose of the Mayor's EPS is to achieve the best environmental outcomes, in carbon terms, for the management of London's municipal waste in addition to the need to meet weight-based recycling and composting targets. Further context for the development of the Mayor's EPS is set out within Policy 2 of the Mayor's Draft Municipal Waste Management Strategy (MWMS).

Arup's review, undertaken in March and April 2011, follows the completion of the Public Consultation of the Mayor's Draft MWMS and sets out to examine the scope, methodology and data assumptions used for developing the Mayor's EPS. Arup has also undertaken a wider, strategic review to assess how the Mayor's EPS contributes to the waste and energy policy context and particularly its effect on the ability of London's boroughs and the region as a whole to meet statutory recycling and composting targets.

The purpose of this report is to present the key findings of the review process and the recommendations advised for the immediate and future revision of the Mayor's EPS. This review process will also be used to make final amendments that may be required to Policy 2 of the Mayor's Draft Municipal Waste Management Strategy (MWMS) prior to its final adoption in 2011.

The Mayor's EPS

The Mayor's EPS has been developed by Eunomia Research & Consulting Ltd (Eunomia), working on behalf of the GLA and in conjunction with a Steering Group. It comprises of two requirements that must be met simultaneously by waste authorities:

- **Whole Waste System EPS:** uses a life cycle approach to encourage waste authorities to focus on material reprocessing and recovery routes that deliver greatest CO_2eq reductions across the waste treatment and disposal lifecycle, thereby reducing CO_2eq emissions associated with their waste management activities. Target performance levels are set at four points in time as based on the net annual CO_2eq emissions associated with London's waste management in 2008/09 and in the future at 2015, 2020 and 2031.
- **Carbon Intensity Floor for Energy Generation (CIF):** a minimum CO_2 emissions performance level which requires that energy generated from waste is no more polluting in carbon terms than the marginal source of energy it displaces. The purpose of the CIF is to provide support for the development of low-carbon, decentralised energy from waste that is no more carbon intense than the source of energy being displaced.

[1] CO_2eq is a metric used to compare the global warming potential of various greenhouse gases, such as methane and nitrous oxides, using the functionally equivalent amount or concentration of carbon dioxide (CO_2) as the reference.

Further information on the development of the Mayor's EPS is contained within Section 1 of this report. Section 2 contains Arup's methodology for undertaking this review. Key findings are presented in Section 3 for the Whole Waste System EPS and in Section 4 for the CIF. More general recommendations, for example, on the presentation of the documents reviewed, communication of the EPS to its audience and general use of terminology and EPS metrics, are contained with Section 5.

Key Recommendations and Conclusions

Overall, the methodology used for developing each constituent part of the Mayor's EPS appears fit for purpose given the availability of information and tools available to help determine greenhouse gas emissions from waste management activities. However, some further refinement of the scope and methodological approach used is required to ensure that the Mayor's EPS is both technically and financially achievable by London's waste authorities. These conclusions are discussed further in Section 7 of this report.

A total of 24 recommendations (summarised in Section 8) have been made to aid the further development of the Mayor's EPS. These recommendations are a mixture of actions that should be addressed immediately and those which should be considered during future, periodic review cycles, for example, when updated or more suitable data becomes available for inclusion within the Mayor's EPS. Revision of the Mayor's EPS will also be supported by additional modelling work that has been undertaken by others in parallel with this review process. Key recommendations for further development of the Mayor's EPS are set out below.

Whole Waste System EPS

The key recommendations made are in relation to the scope of emissions considered within the life cycle assessment (LCA) approach that has been used to specify the performance levels of the Whole Waste System EPS.

Recommendation 3 support the GLA's decision to include re-use activities as a waste management option as and when suitable emissions factor data becomes available. This would enable waste authorities to benefit from the avoided emissions of re-use activities within the scope of meeting the Whole Waste System EPS performance levels.

It is also recommended (Recommendation 8) that emissions from waste-related transportation should be included such that waste authorities can benefit from the potential emissions reductions associated with methods of rail and river transportation. Furthermore, an approach similar to that used within the Scottish Carbon Metric or Protocol for the Quantification of Greenhouse Gas Emissions from Waste Management Activities (EPE Protocol) should be used to facilitate the inclusion of waste-related transport emissions, which are currently a notable exclusion from the LCA approach used (Recommendation 9).

It is not possible to state what effect the inclusion of re-use and waste-related transport emissions might have on the existing performance levels specified for the Whole Waste System without further modelling being undertaken. At the very least, it should provide waste authorities with further flexibility in how to meet the Whole Waste System EPS performance levels. It should also incentivise waste authorities to implement re-use activities as a preferred waste management option and to reduce emissions associated with waste-related transportation.

Other recommendations and comments have been made with respect to the calculation of emissions associated with London's municipal waste management using the emission factors specified for materials recycling and reprocessing and for residual waste management activities. These include a requirement to undertake a detailed peer review of user defined technology processes used within the LCA modelling of the Whole Waste System EPS in line with Environment Agency guidance and best practice (Recommendation 10).[2]

It is also recommended to give further consideration to the use of an emissions factor for open loop recycling of glass (Recommendation 12) and to verify other emissions factors used for some materials recycling processes and residual waste management activities (Recommendations 13 and 14 respectively). It is not envisaged that any changes that might be implemented as a result of these recommendations would be significant enough to alter the Whole Waste System EPS performance levels. However, some further verification is required to provide assurance that the calculation of the associated emissions used to inform the specified performance levels are correct.

Carbon Intensity Floor for Energy Generation

The marginal emissions approach used to determine the specified performance level of the CIF would appear to be suitable based on the fact that CCGT (as the marginal source of energy generation) is that most likely to be displaced by London's waste to energy facilities until at least 2025 (Recommendation 15).[3]

The current specified performance level of the CIF is 387kgCO_2/kWh, which has been calculated by Eunomia on the basis of a modern CCGT power station with an assumed generation efficiency of 55% and calorific value of 39MJ/m³ for natural gas. It is recommended (Recommendation 16), however, that the level of the CIF be raised to at least 393kgCO_2/kWh in line with latest guidance from the Department of Energy and Climate Change, which specifies this as a marginal electricity emissions factor for CCGT.[4] It is also recommended that further modelling work, being undertaken by others in parallel with this review, should be used to inform the specified performance level of the CIF to ensure that it is set at a level which is both technically and financially achievable by the municipal waste sector, given other constraints, such as issues around site selection and planning permission for new waste to energy facilities in London. However, a decision by the GLA to allow waste authorities to offset emissions from energy generation (from technologies such as gasification and incineration) with those associated with use of biogas from anaerobic digestion will also provide further flexibility for waste authorities to decide how best to meet the specified

[2] User-defined technology processes have been created using the Waste and Resources Environment Assessment Tool for the Environment to facilitate the inclusion of certain technology configurations within the lifecycle assessment of greenhouse gas emissions from waste management activities.

[3] Marginal energy generation refers to plant which is most likely to be built or retired (or increase or decrease output) in response to policies resulting in long-term changes to electricity supply or demand.

[4] DECC (2010) Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation [online] available at http://www.decc.gov.uk/en/content/cms/statistics/analysts_group/analysts_group.aspx (accessed April 2011).

performance level alongside the Whole Waste System EPS and recycling and composting targets.

Other Recommendations

Other, more general comments and recommendations have been made with respect to the Mayor's EPS overall. These refer to the implementation of a periodic review cycle for the Mayor's EPS (Recommendation 20) and the need for consistent use of EPS terminology and metrics (Recommendation 22), for example. Further clarity is also required with respect to the implementation of the Mayor's EPS; for example, its application to new contracts, whether it will apply as a benchmark or a standard and the consequences of not being in general conformity with the Mayor's MWMS should the specified performance levels not be achieved.

Policy Considerations

At a strategic level, the Mayor's policy objective to develop an EPS for municipal waste management is consistent with, if not ahead of, emerging national waste policy. DEFRA's waste policy unit, for example, has indicated that it will be considering the development of a carbon metric to be implemented nationally alongside recycling and composting targets. The challenge for waste authorities, however, will be in meeting the specified performance levels of the Mayor's EPS (both Whole Waste System EPS and CIF) alongside statutory recycling and composting targets for 2015 and 2020 (and the Mayor's aspirational target to achieve 60% recycling and composting for 2031). To date, it does not appear that any modelling has been undertaken to demonstrate how all three components can be achieved in a way that is both technically and financially achievable, although it is likely that this will be informed further by the outcomes of further modelling work being undertaken by SLR Consulting for the GLA. It is understood that the results of this further modelling will help to inform the EPS and will be published alongside the Mayor's MWMS. A discussion of the contribution of the Mayor's EPS to both waste and energy policy and existing targets is presented in Section 6 of this report.

Next Steps

The GLA will consider the recommendations made within this Final Report as a basis for the immediate and future revision of the Mayor's EPS, including amendments to Policy 2 of the Mayor's Draft MWMS for final adoption in the Summer of 2011.

1 Introduction

1.1 Overview

Ove Arup & Partners Ltd (Arup) has been commissioned by the Greater London Authority (GLA) to review the approach used to develop a carbon dioxide equivalent emissions performance standard (CO_2eq EPS) for the management of London's municipal waste (Mayor's EPS).[5]

The purpose of the review is to:

- Ensure that a suitable approach has been taken in setting out the scope, methodology and data assumptions used to establish a CO_2eq EPS for municipal waste management in London;
- Conduct a wider strategic review to assess how the Mayor's EPS contributes to the waste and energy policy context; and
- Determine whether or not the Mayor's EPS is likely to be detrimental to implementation of the relevant policy objectives and targets; and
- Make recommendations as to potential revisions that might be required to the EPS.

This report sets out the rationale for the review, the methodology used to undertake the review, finding of the review process and Arup's proposed recommendations as to potential future revisions of the Mayor's EPS.

1.2 Background

The Mayor has a statutory duty to provide strategic direction for the management of London's municipal waste, which accounts for around 20% of London's waste. This strategic direction is set out in the Mayor's Draft Municipal Waste Management Strategy for London (MWMS), which was released for Public Consultation in October 2010.[6] Specific objectives and targets for the management of London's municipal waste are set out in Chapter Five of the Mayor's spatial development plan for London.[7]

London's waste collection and disposal authorities in undertaking their waste functions are required to be 'in general conformity' with the Mayor's MWMS. Consequently, there is a need to ensure that the methodology used to develop the Mayor's EPS is robust, that it is achievable and that its implementation does not contradict existing policy targets and objectives. The GLA has also identified (primarily as a result of responses received during the Public Consultation

[5] A metric used to compare the global warming potential of various greenhouse gases, such as methane and nitrous oxides, using the functionally equivalent amount or concentration of carbon dioxide (CO_2) as the reference.
[6] Greater London Authority (2010) London's Wasted Resource: The Mayor's Draft Municipal Waste Management Strategy for London (Public Consultation Draft, October 2010) [online] available at http://www.london.gov.uk/consultation/waste-strategy (accessed March 2010).
[7] Greater London Authority (2010) The London Plan: Spatial Development Strategy for Greater London (Consultation Draft Replacement Plan, October 2009) [online] available at http://www.london.gov.uk/shaping-london/london-plan/strategy/download.jsp (accessed March 2010).

exercise) that further work is required to verify and refine the approach used for developing the Mayor's EPS. Public Consultation responses that are relevant in the context of the Mayor's EPS are summarised in Appendix A1.

1.3 Purpose of the Mayor's EPS

Climate change mitigation is a key driver in modern day resource and waste management. In line with this approach, Policy 2 of the Mayor's Draft MWMS sets out the intent to develop a CO_2eq EPS to ensure that the best environmental outcomes are achieved for the management of London's municipal waste. The Mayor's EPS uses CO_2eq emissions as an indicator of environmental impact, which also allows for alignment with policy measures for energy and climate change mitigation.

The objectives of the Mayor's EPS are to:

- Reduce the impact of London's municipal waste management activities upon climate change;
- Move municipal waste management in London from a net contributor to a net reducer of climate change; and
- Help focus on reprocessing and recovery routes that deliver greatest CO_2eq emission savings.

The development of a CO_2eq EPS is not a new concept with many examples having been developed for the power generation sector. The first CO_2eq EPS of this type was introduced by the State of California in 2007, with several other US States (including Illinois, Montana, Washington, Oregon and New Mexico) following its lead. The Californian model specifies a limit on the amount of CO_2 a new power station can emit per kWh of electricity generated. It works on the basis that the performance level of any new power station (or renewed contract longer than five years) must be no higher than the annual emissions rate of a combined-cycle gas (CCGT) turbine plant, which is suggested to be 500gCO_2/kWh.[8]

The Department of Energy and Climate Change (DECC) is currently consulting on the introduction of a CO_2eq EPS for power generation as part of the UK Government's statutory consultation on electricity market reform.[9] The Netherlands has also considered the concept but the UK example would be the first of its kind in Europe if implemented.

The traditional basis of municipal waste management performance and diversion from landfill is the use of weight-based recycling and composting targets. The European Waste Framework Directive, which provides the overarching legislative framework for the collection, transport, recovery and disposal of waste within European Member States has a key target to achieve 50% recycling or preparation for re-use by 2020.[10] This target is shown in Table 1 alongside those for England and the Greater London Region.

[8] Applies only to base load plant.
[9] http://www.decc.gov.uk/en/content/cms/consultations/emr/emr.aspxx.
[10] Directive 2008/98/EC On Waste and Repealing Certain Directives (Revised Waste Framework Directive).

Table 1: Recycling and Composting Targets

Target Year	Greater London	United Kingdom	European Union
2015	45%	45%	-
2020	50%	50%	50%
2031	60%	-	-

Recycling and composting targets for England are set out within the Waste Strategy for England 2007, which aims to meet the European requirement to achieve 50% recycling and composting by 2020 in addition to a target to meet 45% recycling and composting by 2015. Alongside these targets, the Waste Strategy for England 2007 sets out the Government's vision for sustainable waste management in England up to 2020.[11] It provides a framework for resource and waste management in accordance with the Waste Framework Directive whilst integrating waste policy into the broader framework of sustainable consumption and production. The objectives of the Waste Strategy for England are to:

- Decouple waste growth from economic growth and place more emphasis on waste prevention and re-use;
- Meet and exceed Landfill Directive diversion targets for biodegradable municipal waste in 2010, 2013 and 2020;
- Increase diversion of non-municipal waste from landfill and secure better integration of treatment for municipal and non-municipal waste;
- Secure the investment in infrastructure needed to divert waste from landfill and for the management of hazardous waste; and
- Get the most environmental benefit from that investment, through increased recycling of resources and recovery of energy from residual waste using a mix of technologies.

The Mayor's targets for recycling and composting of waste in line with those set nationally by the Waste Strategy for England 2007 for the years 2015 and 2020. However, the Mayor has set a further, aspirational target for London to achieve 60% recycling and composting for 2031.[12] The use of weight-based recycling and composting targets as a basis for driving improvements has not always focussed attention on managing materials that have the greatest impact environmentally. The EPS approach has thus been combined with established methods of quantifying greenhouse gas (GHG) emissions from waste management activities to develop a CO_2eq EPS specifically for London's municipal waste management activities.

[11] DEFRA (2007) Waste Strategy for England 2007 [online] available at http://www.defra.gov.uk/environment/waste/strategy/ (accessed March 2011).
[12] Greater London Authority (2010) London's Wasted Resource: The Mayor's Draft Municipal Waste Management Strategy for London (Public Consultation Draft, October 2010) [online] available at http://www.london.gov.uk/consultation/waste-strategy (accessed March 2010).

1.4 Development of the Mayor's EPS

The Mayor's EPS has been developed by Eunomia Research & Consulting Ltd (Eunomia), working on behalf of the GLA and in conjunction with a Steering Group comprising representatives of the following organisations:

- North London Waste Authority;
- East London Waste Authority;
- West London Waste Authority;
- London Borough of Tower Hamlets;
- London Councils;
- London Waste and Recycling Board; and
- Environment Agency.[13]

As shown in Figure 1, the Mayor's EPS has two constituent parts:

- **Whole Waste System EPS (also known as Core EPS):** refers to the net CO_2eq emissions associated with an authority's waste treatment and disposal solution, from the point of arrival at a waste management facility to the final point of treatment and/or disposal. It does not include emissions associated with waste collection and transportation. The Whole Waste System EPS uses a life cycle approach to help waste authorities focus on material reprocessing and recovery routes that deliver greatest CO_2eq reductions across the waste treatment and disposal lifecycle. The Whole Waste System EPS metric is expressed as tonnes of CO_2eq per tonne of waste managed.
- **Carbon Intensity Floor for Energy Generation (CIF)**: a minimum CO_2 emissions performance level which requires that energy generated from waste is no more polluting in carbon terms than the marginal source of energy it displaces. The CIF (expressed as gCO_2/kWh) refers to the CO_2 emissions associated with the energy generated from one tonne of waste, in isolation of other waste treatment processes. The purpose of the CIF is to provide support for the development of low-carbon, decentralised energy from waste that is no more carbon intense than the source of energy being displaced.

Arup has worked with Eunomia throughout the review process to facilitate an understanding of the methodology and assumptions used for developing the Mayor's EPS. SLR Consulting Ltd (SLR) has been commissioned by the GLA to analyse further the financial implications of meeting both the Whole Waste System EPS and CIF. SLR's work has been undertaken in parallel with this review, which considers the initial outcomes of the draft report prepared by SLR in relation to the technical and financial achievability of the Mayor's EPS.

SLR has also undertaken a secondary piece of work to develop a Microsoft Excel-based GHG calculator tool (known as the 'Ready Reckoner Calculator') that will allow waste authorities to model the performance of their waste management services against the Mayor's EPS. The tool is based on the Environment Agency's Waste and Resources Assessment Tool for the Environment (WRATE)

[13] This group has since been widened to include DEFRA, the Environmental Services Association, the South London Waste Partnership and Western Riverside Waste Authority to review additional EPS modelling work being undertaken by SLR on behalf of the GLA.

model for calculating emissions associated with waste management processes and will enable waste authorities to input municipal waste management data (including quantity of waste managed, composition data and material flows) to determine performance against the Mayor's EPS.

The GLA will consider the recommendations made within this Final Report as a basis for the immediate and future revision of the Mayor's EPS, including amendments to Policy 2 of the Mayor's MWMS for final adoption in 2011.

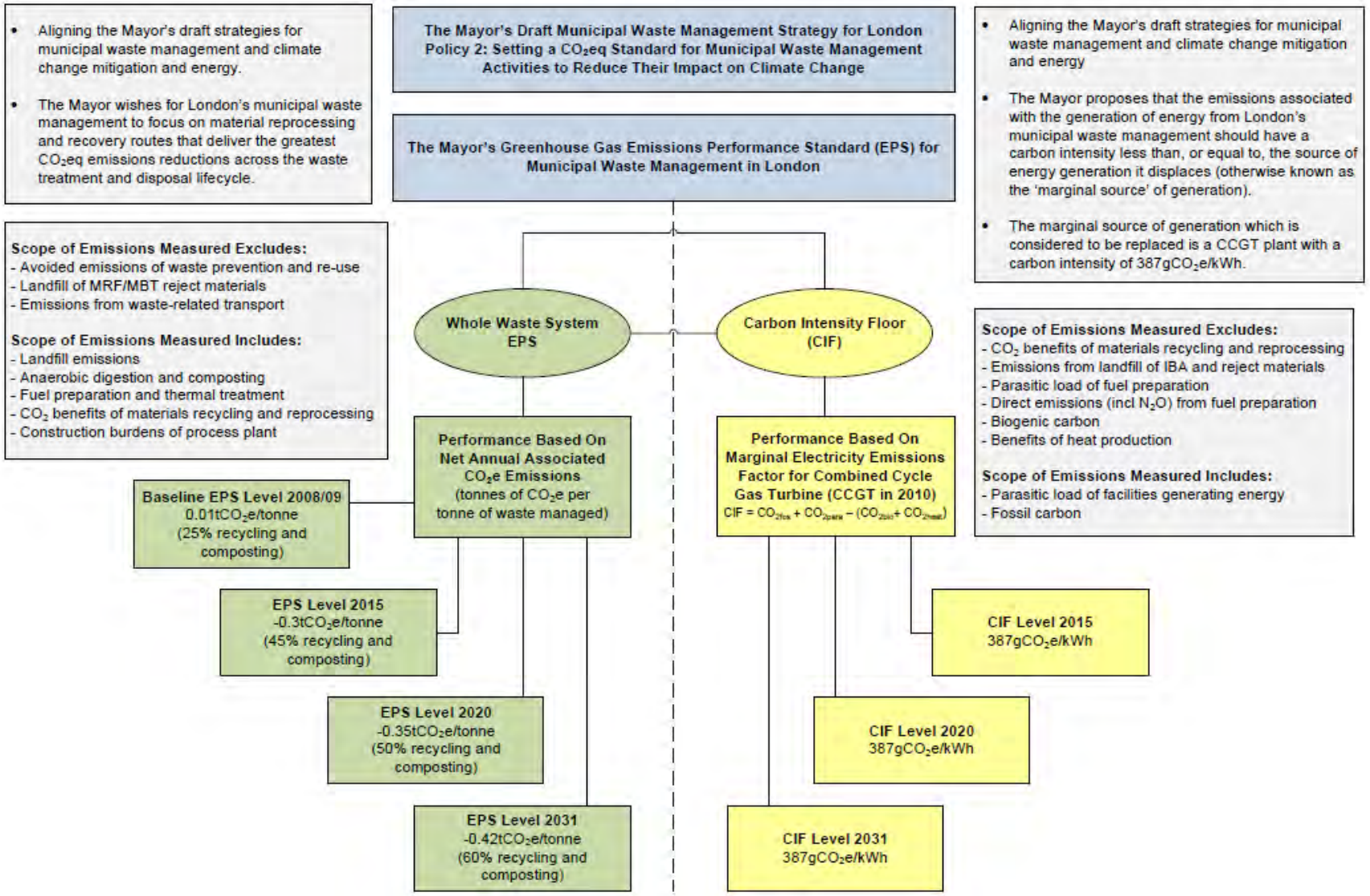

Figure 1: Constituent Parts of the Mayor's EPS

2 Methodology

2.1 Requirements of the Review

Arup's methodology for undertaking the review is set out further below in Section 2.2. It responds to the requirements of the review specified by the GLA as follows:

- Understand and review the methodological approach used to develop the Mayor's EPS to determine that it is robust and not detrimental to the implementation of national waste policy, namely the Waste Strategy for England 2007 and the UK's obligations under the European Union (EU) Waste Framework Directive.
- Determine whether or not the Mayor's EPS compliments the achievement of the Mayor's proposed municipal recycling or composting targets as set out in the Mayor's Draft MWMS.
- Determine, in liaison with DECC and appropriate waste and energy industry colleagues that the methodology used for setting a CIF for energy generated from London's municipal waste is appropriate for the purposes of making an effective contribution towards:
  - The Mayor's renewable energy and carbon reduction targets as set out in his draft Climate Change Mitigation and Energy Strategy; and
  - UK Government carbon reduction and renewable energy targets and commitments.
- Review the rationale for setting the Mayor's municipal recycling and composting targets and demonstrate how these contribute to the achievement of national municipal recycling and composting targets.
- Recommend any further assumptions to help inform the methodology and development of the Mayor's EPS.

2.2 Scope and Methodology

The purpose of this document is to present the findings of the review process and recommended actions for further refinement of the Mayor's EPS. The methodology for undertaken the review process is outlined below in Sections 2.2.1 to 2.2.5 of this report.

2.2.1 Ongoing Project Review

A series of project meetings have been held between Arup and the GLA throughout the duration of the project as follows:

- A Project Inception meeting was held on 23 February 2011 to agree the approach for undertaking the work and to agree key milestones and project delivery dates as set out in Arup's indicative Project Programme.

- A Progress Review Meeting was held on 15 March 2011 to discuss the initial outcomes of the review process and potential recommendations prior to preparation of an initial draft report for the GLA's review.
- A Final Project Meeting was held on 4 April 2011 to discuss the outcomes of the project and receive the GLA's comments on the initial draft findings and recommendations prepared by Arup.

2.2.2 Review Scope, Methodology and Assumptions of the Mayor's EPS

The scope, methodology and assumptions used to develop the Mayor's EPS have been reviewed from the following publicly available documents:

- London's Wasted Resource: The Mayor's Draft Municipal Waste Management Strategy for London: Public Consultation Draft, October 2010;
- Appendix 4a to the Mayor's Draft MWMS: Economic Modelling for the Mayor's Municipal Waste Management Strategy (Main Report and Appendices); and
- Appendix 4b to the Mayor's Draft MWMS: Development of a CO_2eq Emissions Performance Standard for the Management of London's Municipal Waste (Main Report and Appendices).

Supplementary information has also been obtained as a result of ongoing direct discussion with Eunomia and also from the WRATE modelling files provided by Eunomia. WRATE is a lifecycle assessment (LCA) tool designed specifically to determine the environment impacts associated with waste management processes. It uses a whole lifecycle approach to determine the impacts associated with waste collection, transportation, treatment and disposal. It has, therefore, been used by Eunomia to provide data for modelling of CO_2eq emissions associated with London's municipal waste management activities.

2.2.3 Review of Alternative EPS and Waste Management Greenhouse Gas Emission Assessment Methods

Arup has reviewed other CO_2eq EPS and life cycle assessment approaches to the quantification of GHG emissions from waste management activities to assess:

- Whether the approach used to develop the Whole Waste System EPS and CIF is consistent with other national and international approaches; and
- How the specified level of the CIF aligns against those of other CO_2eq EPS identified and whether it is an appropriate benchmark in the context of London's municipal waste management and decentralised energy generation.

Other CO_2eq EPS have been identified through with stakeholders, including DECC and the Department for the Environment Food and Rural Affairs (DEFRA) and from desk-based research of the following published information:

- House of Commons Energy and Climate Change Committee (2010) Emissions Performance Standards: First Report of Session 2010-11, Volume I;[14]
- House of Commons Energy and Climate Change Committee (2010) Emissions Performance Standards: First Report of Session 2010-11, Volume II Additional Written Evidence;[15] and
- DECC (2010) Electricity Market Reform Consultation Document.[16]

Life cycle assessment approaches to the quantification of GHG emissions associated with waste management activities have been reviewed as follows:

- The Carbon Metric Reporting System for Recycling Performance developed by Zero Waste Scotland and the Scottish Government (Scottish Carbon Metric); and [17]
- The Protocol for the Quantification of Greenhouse Gas Emissions from Waste Management Activities developed by *Entreprises pour l'Environnement* (EPE Protocol).[18]

Further information about the Scottish Carbon Metric and EPE Protocol is contained in Appendix A2 and Appendix A3 respectively.

2.2.4 Appraisal of EPS against Policy Context

Arup has identified the relevant policy objectives and targets for waste and energy at EU, national and regional level and used professional judgement to determine:

- How the EPS contributes, or otherwise, to EU, UK and Greater London regional policy objectives and targets for waste and energy;
- If the EPS benchmark complements, or would otherwise compromise the ability to meet, national and regional recycling and composting targets; and
- Whether the EPS is likely to lead to potential conflict between waste collection and disposal strategies and how it may influence the selection of waste infrastructure technologies that may, or may not, be appropriate for contributing to waste and energy policy targets and objectives.

2.2.5 Stakeholder Liaison

A half-day workshop was held on 10 March 2011 to discuss in detail the approach to developing the CIF. The workshop was attended by representatives of the following organisations:

[14] House of Commons Energy and Climate Change Committee (2010) Emissions Performance Standards: First Report of Session 2010-11, Volume I [online] available at http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/publications/ (accessed March 2011).
[15] House of Commons Energy and Climate Change Committee (2010) Emissions Performance Standards: First Report of Session 2010-11, Volume II Additional Written Evidence [online] available at http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/publications/ (accessed March 2011).
[16] DECC (2010) Electricity Market Reform Consultation Document http://www.decc.gov.uk/en/content/cms/consultations/emr/emr.aspx (accessed March 2011).
[17] http://www.zerowastescotland.org.uk/carbon_metric/carbon_metric.html.
[18] http://www.epe.asso.org/index_en.php?part=publi&id_rap=20.

- Arup;
- Greater London Authority;
- Eunomia Research & Consulting Ltd;
- London Development Agency;
- Department for the Environment, Food and Rural Affairs; and
- Department of Energy and Climate Change.

The opportunity was taken to present and discuss initial findings with those present, particularly with respect to assessing whether or not the Mayor's EPS would make an effective contribution towards renewable energy and carbon reduction targets for the UK and Greater London.

The key questions discussed at the Workshop were as follows:

- What is the key rationale for the CIF and are there are other existing mechanisms available that would achieve the same outcome?
- If a CIF is required, what is an appropriate methodology for specifying the level of performance that should be achieved?
- On what basis have other CO_2eq EPS been developed?
- Once an appropriate methodology has been established, at what level should the CIF be set and would this be achievable for existing and proposed waste to energy facilities?

Other *ad hoc* discussions have also been undertaken with waste policy representatives from DEFRA's Waste Policy Unit to discuss the policy implications of the Mayor's EPS.

In order to ensure that any concerns about the development of the Mayor's EPS have been considered during the review, Public Consultation responses related to Policy 2 (Mayor's EPS) and Policy 4 (London's Recycling and Composting Targets) of the Mayor's Draft MWMS were obtained from the GLA and considered as part of the review.

2.3 Limitations to Scope of Work

Arup's agreed scope of work has not included the undertaking of a detailed peer review of any WRATE User Defined Processes (UDPs) created by Eunomia for the development of the Mayor's EPS.[19] The use of UDPs within the Mayor' EPS is discussed further within Section 3.3.

The detailed assumptions contained within Appendix 4a to the Mayor's Draft MWMS (Economic Modelling for the Mayor's Municipal Waste Management Strategy) have not been reviewed in detail. This is effectively a separate study in its own right, undertaken by Eunomia prior to the development of the Mayor's

[19] The creation of a UDP involves duplication and amendment of an existing technology process within the WRATE model, for example, changes to the energy efficiency of a process or the process emissions generated. This usually entails a change to the 'allocation rules' that determine how the technology process behaves in the model. The Environment Agency advises that all UDP processes, and life-cycle assessments (LCA) using UDPS that are published externally are subject to peer review in their own right by an independent third party.

EPS. It is only been reviewed to the extent necessary to determine the suitability of the approach used to developing the Mayor's EPS.

Eunomia has modelled the associated CO_2eq emissions for municipal waste management in London using Waste Data Flow information for 2009/10. It has not been considered necessary to review the draft report prepared by Eunomia as the exercise has been undertaken simply to track performance against the Whole Waste System EPS trajectory. It has not been used to replace the 2008/09 baseline data used to forecast municipal waste arisings and waste management scenarios for 2015, 2020 or 2031.

With respect to the development of the Whole Waste System EPS, Eunomia has not been able to provide its proprietary background spreadsheets used to calculate the numbers provided in Appendix 4b to the Mayor's Draft MWMS (data has been taken from WRATE and entered into a bespoke tool used to calculate associated emissions). As such, it has not been able to fully replicate and verify the Whole Waste System EPS performance levels provided. Further explanation and associated recommendations are provided in Section 3.

3 Findings: Whole Waste System EPS

3.1 Methodology

3.1.1 Economic Modelling

The basis of the approach used to develop the Whole Waste System EPS is the Economic Modelling Study, undertaken by Eunomia on behalf of the GLA, in 2010. The results of this study are publicly available and presented in Appendix 4a to the Mayor's Draft MWMS.

As discussed in Section 2.3, the scope and assumptions used in the Economic Modelling Study have not been reviewed in detail due to this being a separate study in its own right. However, from the review that has been carried out, it would appear that the Economic Modelling Study provides a suitable basis upon which to base the Whole Waste System EPS.

The study assesses the costs of meeting the Mayor's proposed recycling and composting targets for 2015, 2020 and 2031 and uses 2008/09 Waste Data Flow information for London as a baseline to forecast the quantities of municipal waste required to be managed in each of the three target years. The Economic Modelling Study modelled 11 waste management scenarios based upon different combinations of collection, treatment and disposal scenarios.[20] These scenarios, each of which has been assessed on the basis of financial performance and monetised GHG emissions, promote a broad approach as to how the Mayor's recycling and composting targets can be achieved based on different collection and treatment strategies.

The Economic Modelling Study determined that six of these scenarios would meet the Mayor's recycling and composting targets for London in each of the three target years using options that would be both technically feasible and achievable within the practical constraints of London's housing stock and the time necessary to build new waste facilities.

It is noted that capture rates used within the study have been developed using information published in the Waste & Resource Action Programme (WRAP's) Analysis of Kerbside Dry Recycling Performance in England 2007/08. This publication was updated in September 2010, its scope having been extended to cover all local authorities in the UK (not just England).[21] The other key difference reported is that the updated WRAP report now also includes 2008/09 benchmark data for textiles collected at the kerbside (data that as not included previously). It has been confirmed that capture rates for textiles were included in the original Economic Modelling Study based on Eunomia's own internal analysis of London borough performance.

[20] Collection strategies focus either on food wastes or dry recyclables. Scenarios also model roll-out and performance of different waste treatment technologies.
[21] WRAP (2010) Analysis of Kerbside Dry Recycling Performance in the UK 2008/09 [Online] available at http://www.wrap.org.uk/local_authorities/research_guidance/collections_recycling/benchmarking.html (accessed March 2011).

Recommendation 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 future updates to the Whole Waste System EPS.

3.1.2 Whole Waste System EPS Performance Level

The performance level of the Whole Waste System EPS is based on the net annual CO_2eq emissions associated (referred to hereafter as 'associated emissions') with the total quantity of waste to be managed in the baseline year (2008/09) and each of the three target years (2015, 2020 and 2031). Thus, the performance level changes on a trajectory over time according the quantities of waste to be managed.

Associated emissions have been calculated for each of the six Economic Modelling scenarios that meet the Mayor's recycling and composting targets. The specified performance level has then been selected on the basis of the lowest performing of the six scenarios (i.e. the scenario forecast to have the greatest level of associated emissions in this year).

Recommendation 2: It has been confirmed the Whole Waste System EPS is based on the associated emissions for Scenario One ('Focus on Dry and Low Biomass New Technologies') as shown in Appendix 4b of the Mayor's Draft MWMS. However, this should be stated explicitly within Appendix 4b to the Mayor's Draft MWMS.

3.2 Scope of Associated Emissions

The following waste management activities have been excluded from the scope of associated emissions for the baseline and target years:

- Emissions savings associated with waste prevention and re-use;
- Emissions associated with incinerator bottom ash (IBA) to landfill;
- Emissions associated with reject streams from materials recycling facilities (MRF) and mechanical biological treatment (MBT) to landfill; and
- Emissions associated with transportation of waste.

3.2.1 Waste Prevention

The Whole Waste System EPS assumes that the Mayor's targets for reduction of waste will already have been met. Thus, waste reduction is already accounted for in the Whole Waste System EPS performance levels as a result of the waste growth factors used to forecast municipal waste arisings for 2015, 2020 and 2031.[22]

The specified performance levels of the Whole Waste System EPS do not take into account any further waste reduction beyond that which has already been forecast. However, waste authorities would be able to take advantage of further

[22] Mayor's target to reduce the amount of household waste produced from 970kg per household in 2008/09 to 790kg per household by 2031, equivalent to a 20% reduction per household. This is set out in the Mayor's Draft MWMS.

associated emissions reductions since the Whole Waste System EPS only accounts for those associated with the waste that is subsequently created.

The EPE Protocol, which has similar system boundaries to the Whole Waste System EPS, does not consider waste prevention but it is included within the scope of the Scottish Carbon Metric. The scope of the LCA approach used by the Scottish Carbon Metric is wider than the system boundaries within WRATE in that it considers quantification and comparison of environmental impacts associated with specific products and supply chains (as well as end-of-life waste management options). This supports its function to act also as a tool to inform resource and waste management policy in relation to specific products and materials at a national level.

To this end, the Scottish Carbon Metric includes information on extraction and manufacturing processes, which means that emissions associated with waste prevention in the supply chain can be included (considered as avoided emissions from manufacturing). The Whole Waste System EPS has not been designed with these impacts in mind but an approach similar to that used by the Scottish Carbon Metric could be adopted for use in the Whole Waste System EPS to enable authorities to benefit further from these avoided emissions. This would encourage waste authorities to consider further the environmental benefits of waste prevention, in line with the preferred approach of the waste hierarchy. The Carbon Trust has not commented on the inclusion of waste prevention in its peer review report of the Scottish Carbon Metric, other than to mention that it would help to highlight the merits of alternative waste management options, including prevention.[23]

3.2.2 Re-use

Re-use activities have been excluded due to uncertainty over the appropriate emissions factors for re-use routes and because there is no process within WRATE to model this activity.[24] The difficulties in incorporating re-use data are acknowledged by Zero Waste Scotland in its development of the Scottish Carbon Metric. Likewise, re-use is also not featured within the scope of the EPE Protocol.

The only re-use activity currently accounted for in the Scottish Carbon Metric is textiles, where re-use is assumed as the predominant destination of material recorded as 'recycled'. As highlighted by the Carbon Trust in its peer review of the Scottish Carbon Metric, however, the inclusion of textiles emission factors appears to be based on an, as yet, unpublished study.[25] The technical report for the Scottish Carbon Metric confirms that suitable re-use data for other materials and products is limited.[26] It does, however, refer to a number of other sources that

[23] Carbon Trust Advisory Services (2011) Review of Methodology for the Carbon Metric for Scotland (Final Report) [online] available at http://www.zerowastescotland.org.uk/carbon_metric/carbon_metric.html (accessed March 2011).
[24] For example, associated emissions for the baseline year, as shown in Table 2.1 to Appendix 4b of the Mayor's MWMS, exclude 10,000tpa of waste sent for re-use.
[25] Carbon Trust Advisory Services (2011) Review of Methodology for the Carbon Metric for Scotland (Final Report) [online] available at http://www.zerowastescotland.org.uk/carbon_metric/carbon_metric.html (accessed March 2011).
[26] Zero Waste Scotland (2011) Final Report: The Scottish Carbon Metric [online] available at http://www.zerowastescotland.org.uk/carbon_metric/carbon_metric.html (accessed March 2011).

it recommends should be explored further with respect to emission factors for re-use. It fully intends to incorporate re-use activities when more appropriate information becomes available that meets its specified data quality indicators.

Recommendation 3: As a waste management option, re-use should be included within the scope of associated emissions for the Whole Waste System EPS.

Whilst the quantities of waste managed for re-use may be relatively small (e.g. 10,000tpa (less than 1%, of waste in the baseline year) the emissions savings may be greater as a proportion of overall associated emissions. In the context of meeting the Whole Waste System EPS, this would allow waste authorities to take advantage of the benefits of managing waste at the top of the waste hierarchy.

The GLA is currently working with the London Community Resource Network (LCRN) to obtain better data for re-use emissions savings. It is understood that DEFRA is also proposing to publish emissions factors as part of collaborative work being undertaken with WRAP.

Recommendation 4: It is advised that consideration be given to the system boundaries of the LCA studies used to provide this information to ensure that the scope of re-use emissions data used is consistent.

As indicated by the Carbon Trust in its peer review of the Scottish Carbon Metric, the avoided waste from re-use of a domestic appliance may provide significant carbon emissions savings but the extended use of an inefficient compliant could have a negative impact compared to replacement with a more efficient model. There are, as such, two elements to re-use related carbon emissions:

- The avoided emissions of re-use as a waste management option; and
- The emissions associated with the operation of a re-used product (and relative to those associated with a newer model).

Recommendation 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.

It is not possible to state, at this time, how inclusion of re-use might affect the specified performance levels of the Whole Waste System EPS (although quantities are relatively small, they would need to be considered in conjunction with the relative emissions factors). It is not expected that the specified performance levels would change but this should be considered as and when suitable data becomes available for inclusion of re-use within the scope of the Whole Waste System EPS.

3.2.3 Incinerator Bottom Ash and Reject Material from MRF and MBT

Emissions associated with the landfill of IBA and reject material from MRFs and MBT have been excluded on the basis that the composition of these materials, and their impact on landfill, cannot be modelled accurately in WRATE. Furthermore, that these material streams are likely to be largely inert with little impact on

emissions from landfill.[27] It should be possible to model this information within WRATE (for example, using municipal waste composition data for London or for England) to give a reasonably fair representation of the level of associated emissions that might occur. The composition and distribution of reject material from a MRF or MBT process to landfill (based on a specified reject rate) should be visible within a WRATE project scenario, which could be set up to provide an indicative composition for modelling purposes. Other readily available information on the composition of reject material from MBT is limited but a study undertaken by Enviros Consulting on behalf of WRAP (MRF Quality Assessment Study: Material Quality Assessment of Municipal MRFs within the UK) provides published composition data for MRF residues which could be used to provide an indicative composition for this particular reject stream.[28]

Recommendation 6: For completeness, composition data for these 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.

3.2.4 Transport

Emissions associated with the transportation of waste are a notable exclusion from the Whole Waste System EPS, the reasons for which are outlined in full Appendix 4b to the Mayor's Draft MWMS. The prime reason for this is stated to be the difficulty inherent in modelling such emissions on a London-wide basis, i.e. it would be difficult to model to a reasonable degree of accuracy given the variation in waste transportation systems operated in London. Furthermore, it is stated that waste-related transport emissions, when modelled within WRATE, typically account for around 5% to 10% of the total CO_2eq emissions from waste management activities. Thus, the contribution of waste-related transport impacts to the associated emissions within the Whole Waste System EPS was considered to be negligible.

Recommendation 7: A larger proportion of London's waste is being exported for treatment and disposal facilities to neighbouring counties compared to other cities. The statement that waste-related transport emissions typically account for a small percentage of the total CO_2eq emissions from waste management activities should be verified.

In relation to the aim of the Mayor's EPS to reduce emissions associated with waste management activities in London, the EPS Steering Group concluded that sufficient other mechanisms are available that would provide a strong incentive for local authorities to reduce emissions associated with waste transport. These are:

[27] Associated emissions for the baseline year exclude those for 176,000tpa of IBA and reject material from MRFs and MBT. Eunomia estimates that around 50,000tpa of this is inert material and would have minimal impact on landfill emissions.
[28] Enviros Consulting (2009) MRF Quality Assessment Study: Material Quality Assessment of Municipal MRFs within the UK [online] available at http://www.wrap.org.uk/recycling_industry/publications/mrf_quality_study.html (accessed April 2011). Figure 3 and Appendix 2 (Table A2.1) provide composition information for MRF residues.

- The former National Indicator (NI) 185: agreed to provide sufficient incentive for waste authorities to reduce operations from transport emissions;[29]
- Transport for London (TfL) Fright Operator Recognition Scheme (FORS): designed to help boroughs reduce emissions from fleet vehicles; and
- Waste-related transport costs which are estimated to make up around half of total waste management costs.

NI 185 has since been abolished as a National Indicator although there is still a requirement from DECC for local authorities to collect and report this data.[30] The purpose of this is to allow individual local authorities to benchmark their own performance each year such that they can assess the potential for emissions reductions within their operations. However, the data reported is aggregated under the categories of fleet vehicles, business travel, other and transport total.[31] As such, there may be less incentive to consider the potential for emissions reductions specifically for waste-related transport alone.

Likewise, FORS is a scheme that considers CO_2eq emissions from all types of fleet vehicles. It is also a voluntary scheme, which works on a tiered membership basis, and only requires the measurement and reporting of emissions data from silver membership level upwards. There is no requirement for operators to attain silver membership and no local authorities have yet reached this level. Furthermore, only 16 out of 33 London boroughs have signed up to the lowest membership tier, which means that its' purpose to encourage operators to reduce fleet emissions (and specifically from waste-related transport) is also untested.

The main disadvantage to the exclusion of waste-related transport impacts is that the benefits of sustainable modes of waste transport, such as waste by rail and water, are being missed. This is contradictory to the promotion of alternative modes of transport for waste transport as contained within Policy 5 of the Mayor's Draft MWMS. It is also not known whether NI 185 or FORS would provide the right level of incentive for local authorities to specifically consider waste-related transport emissions as would be necessary within the Whole Waste System EPS.

The ability of local authorities to collate and provide waste-related transport data should not be considered burdensome since it would still need to be collated as part of the overall reporting requirements for the revised NI 185 (now referred to as 'Sharing Information on Greenhouse Gas Emissions from Local Authority Own Estate and Operations').

Under the revised NI 185, local authorities are required to measure GHG emissions[32] in line with DEFRA's 'Guidance on How to Measure and Report

[29] http://www.decc.gov.uk/en/content/cms/statistics/indicators/ni185/ni185.aspx .
[30] Definition of emissions under the former NI 185 was CO_2eq emissions from operations of local authorities associated with the delivery of functions and services, including any services outsourced to a contractor. 'Functions' covers all duties and powers of a local authority.
[31] See DECC (2010) CO_2 Emission Estimates from Local Authority Operations during 2008/09: http://www.decc.gov.uk/publications/basket.aspx?FilePath=Statistics%2fnationalindicators%2f39-ni185-methodology.pdf&filetype=4&minwidth=true for an example.
[32] Measures emissions from the six GHG covered by the Kyoto Protocol – carbon dioxide (CO_2), methane (CH_4), hydrofluorocarbons (HFCs), nitrous oxide (N_2O), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). DEFRA conversion factor spreadsheets are provided to convert raw data into carbon dioxide equivalent emissions.

Your Greenhouse Gas Emissions, September 2009'.[33] Whilst it is no longer a requirement for data to be submitted to Central Government, local authorities must publish a GHG report locally and notify DECC as to its whereabouts within the public domain. DECC's requirement is for this information to be published in terms of carbon dioxide emissions (not CO_2eq) although DEFRA conversion factor spreadsheets are available to convert raw data into CO_2eq also. DECC has stated that data for 2009/10 and 2010/11 should be published by no later than 30 June 2011, which means that data on waste-related transport for London should be available within the public domain shortly.

Recommendation 8: On this basis, 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 waste authorities can benefit from the potential emissions reductions associated with methods of rail and river transportation.

3.2.5 Modelling Waste-Related Transport Emissions

The difficulty in modelling waste-related transport emissions for the purpose of setting the Whole Waste System EPS performance levels is understood but information from local authorities should be available to undertake this work (as discussed in Section 3.2.4). The modelling of waste transportation arrangements within WRATE is also a standard requirement within the procurement process for new waste management infrastructure.[34]

Emissions associated with the transportation of waste are included within the scope of the EPE Protocol. The EPE Protocol Excel Tool for the Calculation of Emissions from Different Waste Activities (Version 4, June 2010) provides waste transport emission factors for natural gas, petrol, diesel, LPG and 'other' fuel types expressed as kgCO_2eq per litre of fuel.[35] The EPE Protocol also allows for average fuel consumption to be entered (in terms of litres per 100km travelled), which can then be multiplied against the stated emissions factors.

Not only does the EPE Protocol calculate direct emissions from waste-related transport (i.e. those associated with the combustion of the fuel) but it also allows for indirect emissions to be taken into account (i.e. those associated with the production of electricity that is used by electric or hybrid vehicles that might be operated by an authority (or private company also for the EPE Protocol).

The emissions factors used within the EPE Protocol are for road haulage and have been taken from a combination of sources; in this case either the French Environment and Energy Management Agency (ADEME) or the IPCC. Where an alternative mode of transport is required (e.g. rail, shipping, river transport), or if the user wishes to estimate emissions in tonnes of CO_2eq/km, the EPE Protocol states that an alternative GHG emissions calculation tool, developed by EPE and

[33] DEFRA (2009) Guidance on How to Measure and Report Your Greenhouse Gas Emissions, September 2009 [online] available at http://www.defra.gov.uk/publications/2011/03/25/greenhouse-gas-emissions-pb13309/ (accessed March 2011).
[34] WRATE has the ability to model movement of waste by rail transport, sea container and barge.
[35] http://www.epe-asso.org/index_en.php?part=publi&id_rap=20.

ADEME can be used. Further details are available within the main EPE Protocol document.[36]

The Scottish Carbon Metric, by comparison, uses transport distance and vehicle information from WRATE to facilitate the inclusion of waste-related transport impacts within its scope.[37] This data has been simplified to provide average transportation distances and vehicle types that can be applied on a similar basis. Information from DEFRA[38] and the Greenhouse Gas Protocol Guidelines[39] has been used to provide vehicle emissions data although it has been recommended by the Carbon Trust (in its peer review of the Scottish Carbon Metric) to upgrade to recently available 2010 data. As an example, transport information used in the calculation of the Scottish Carbon Metric is shown in Appendix A4.[40] Consideration has also been given to average loading factors (including return journeys). A 50% loading assumption has been used for waste vehicles, which leave a depot empty and return fully laden; this reflects the change in load over a collection round which could be expected.

The point to which waste materials are transferred is also considered, hence the inclusion of transport information for both road and international sea freight. For HGVs, an average loading factor (including return journeys) of 56% is used based on information taken from DEFRA's Greenhouse Gas Conversion Factors.[41] For international sea freight, a trade imbalance between Europe and the Far East, means that vessels return empty (but with ballast) unless carrying materials for recycling. In these cases, only the marginal emissions have been taken into account (i.e. those incurred by moving the additional weight of the freight but not the vessel itself).

Recommendation 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.

The Scottish Carbon Metric is likely to provide a more familiar solution due to its use of WRATE but it depends on how associated emissions are calculated overall outside of this model. Discussion would be needed with waste authorities to assess the extent and suitability of data that would be available for inclusion in the Whole Waste System EPS. The validity of the Scottish Carbon Metric waste transportation figures (presented in Appendix A4) could also be assessed for use in the London context.

To add weight to this recommendation, any measurement tools designed for use by waste authorities should work to the same system boundaries. The GHG calculator tool being developed by SLR (to enable waste authorities to measure performance against the Whole Waste System EPS) does include waste-related

[36] Protocol for the Quantification of Greenhouse Gas Emissions from Waste Management Activities [online] available at http://www.epe-asso.org/index_en.php?part=publi&id_rap=20. (accessed March 2011).
[37] The Scottish Carbon Metric also uses other data sources to include transport emissions associated with transport of raw materials to factory for manufacture and distribution to retail distribution centres and retailers.
[38] http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm.
[39] http://www.ghgprotocol.org/files/ghgp/tools/co2-mobile.pdf.
[40] Taken from Table 4.2 of the Scottish Carbon Metric Technical Report.
[41] http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm.

transport and so consideration should be given to its inclusion in the Whole Waste System EPS.

3.3 Calculating Associated Emissions

Associated emissions have been calculated using emissions factors taken from WRATE. Emissions factors for recycled and reprocessed materials, and those for residual waste management treatment and disposal, are shown in Table 2.2 (see Appendix A5) and Table 14 (see Appendix A6) of Appendix 4b to the Mayor's Draft MWMS respectively. Associated emissions for the baseline year are shown in Table 2.1 (see Appendix A7) and those for the three target years of 2015, 2020 and 2031 are shown in Table 2.3 (see Appendix A8).

Since it has not been possible to review Eunomia's proprietary worksheets for the calculation of associated emissions, an attempt has been made to replicate this exercise for the baseline year, based on the waste arisings data shown in Table 2.1 and the emissions factors provided. The results of this exercise are shown in Appendix A9 and discussed further below in Sections 3.3.1 and 3.3.2

Eunomia has created a series of WRATE UDPs to facilitate the inclusion of a range of technology configurations and related assumptions in the calculation of associated emissions. The creation of a UDP involves duplication and amendment of an existing technology process within the WRATE model, for example, changes to the energy efficiency of a process or the process emissions generated. This usually entails a change to the 'allocation rules' that determine how the technology process behaves in the model. The Environment Agency advises that all UDP processes and LCA scenarios using these processes (particularly those that are published externally) are subject to peer review in their own right by an independent third party to provide assurance in the accuracy and completeness of data. WRATE itself has also been peer reviewed and developed in conjunction with the International Standard ISO 14040 series for LCA.

It has been confirmed that the WRATE UDPs created have not yet been peer reviewed in this way. Nor has Arup undertaken this process within the scope of this particular study (which considers more the overall approach used for developing the Mayor's EPS, of which WRATE is a part).

Recommendation 10: WRATE UDPs, which have been 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 to provide assurance in the accuracy and completeness of the data.

3.3.1 Emissions Factors for Recycling and Reprocessing

Open and Closed Loop Recycling

Table 2.2 (Appendix 5) provides emissions factors for materials recycled in a closed loop system (with the exception of food and garden waste where closed loop recycling is not possible so open loop recycling is assumed based on whether the material is sent for composting or anaerobic digestion). This is consistent with the approach used in the Scottish Carbon Metric with the exception of glass, a proportion of which is assumed to be sent to open-loop recycling. The Scottish

Carbon Metric makes the distinction between colour-sorted glass and mixed glass as follows:

- Colour-sorted glass is assumed to go to a closed loop recycling system.
- For mixed collections, a proportion (56%) is assumed to be sent for container re-melt (closed loop system) with the remainder (44%) being used as aggregate replacement (open loop system).[42]

Other than for food and garden waste, the Whole Waste System EPS deliberately uses emissions factors for closed-loop recycling in order to encourage waste authorities to consider methods of collection and treatment that deliver high quality recyclate for reprocessing. However, complete colour separation of glass from the municipal, and particularly household, waste stream is likely to be difficult to achieve. Colour separated glass that is suitable for container re-melt is most likely to be collected from bottle banks. A WRAP report on quality of material outputs from MRFs, for example, also states that glass outputs have proved difficult to use for container re-melt due to non-glass contamination and cross-contamination of different colours that occurs during co-mingled collection. Consequently, very little glass output from MRFs goes to contain re-melt applications, with the majority going to aggregate, despite the increased use of near-infrared sorting equipment.[43]

Recommendation 11: Consideration should be given to the practicalities of achieving 100% colour separation of glass from municipal waste collections for closed-loop recycling. 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.

Changes to Previously Published Emissions Data

A revised Appendix 4b to the Mayor's Draft MWMS has been provided by Eunomia for review as part of the GLA's annual monitoring of the development of the Mayor's EPS. This is to take account of new information as it becomes available that is suitable for inclusion within the Mayor's EPS.

The revised report updates the associated emissions for four of the materials specified under the recycling and reprocessing waste management activity in Table 2.1 (Appendix A7). The previous and amended associated emissions are shown below in Table 2. It has been confirmed that the changes were simply due to a transposition error of information into the report and not as a result of any inaccuracies relating to the quantity of waste managed or the individual emissions factors used.

[42] Split is based on information from Valpak.
[43] WRAP (2009) MRF Output Material Quality Thresholds: A Report on Materials Quality Standards, Quality Measurement Techniques and their Implementation by UK MRFs and Materials Reprocessors [online] available at http://www.wrap.org.uk/recycling_industry/publications/mrf_q_thresholds.html (accessed April 2011).

Table 2: Changes to Associated Emissions for the Baseline Year 2008/09

Material	Associated Emissions ($ktCO_2eq$) (August 2010 Report)	Associated Emissions ($ktCO_2eq$) (February 2011 Report)
Ferrous Metals	-135.00	-80.30
Non-Ferrous Metals	-28.86	-135.00
Plastics	-52.63	-28.86
Textiles	0.03	-52.63

Emissions Factor for Wood

It has been noted that no emissions are shown for wood in Table 2.1 for 33,000tpa managed in the baseline year (see Appendix A7) although an emission factor from WRATE has been provided in Table 2.2 (see Appendix A5). It has been confirmed that the emissions are shown as zero when aggregated to tonnes CO_2eq due to the relatively small tonnage and because the emissions factor is near to zero (stated as 0.968kgCO_2eq/tonne in Table 2.1) relative to other emission factors.

Recommendation 12: This does not impact on the associated emissions for the baseline year but its omission from Table 2.1 (see Appendix A7) should be qualified in the report.

Emissions Factors for Open Windrow Composting and Ferrous Metals

When calculating associated emissions from data provided in Table 2.1 (see Appendix A7) of Appendix 4b to the Mayor's Draft MWMS and the stated emissions factors, there appear to be some discrepancies for emissions associated with individual waste management activities and materials, which are hidden when figures are aggregated to the net associated emissions figure expressed in tCO_2/tonne of waste managed.

In most cases, the discrepancies are negligible (i.e. +/- 1.0 $ktCO_2$) but those for open windrow composting and non-ferrous metals appear to be significantly more different and should be checked for accuracy.

Recommendation 13: It is recommended to verify the emissions factors reported in Appendix 4b to the Mayor's Draft MWMS for these material streams to ensure that the correct figure has been used and/or reported for the baseline and future target years.

3.3.2 Emissions Factors for Residual Waste Management

It is not clear how the associated emissions for residual waste management in Table 2.1 of Appendix 4b of the Mayor's Draft MWMS (which are shown only by waste management activity) have been calculated using the emissions factors specified in Table 14 of the same document. Table 14 also does not provide an emissions factor for MBT, which is stated as a waste management activity in Table 2.1.

Arup has back-calculated the residual waste emission factors used from the data provided in Table 2.1 of Appendix 4b to the Mayor's Draft MWMS and used these figures to replicate the associated emissions for the baseline year. Taking into account the issues discussed in Section 3.3.1 (changes to previously published emissions data and emissions factors for wood, open windrow composting and

ferrous metals), Arup's estimated Whole Waste System EPS value of 0.01tCO_2eq/tonne waste managed for the baseline year concurs with that estimated by Eunomia. However, this may or may not be the case further to verification of the residual waste emissions factors provided, which in turn may or may not affect the stated Whole Waste System EPS performance levels.

Recommendation 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) so that this exercise can be replicated to verify the performance levels of the Whole Waste System EPS for the baseline and target years.

4 Findings: Carbon Intensity Floor

4.1 Methodology

4.1.1 Approach to Specifying a CIF

The purpose of the CIF is to provide support for the development of decentralised energy from waste that is no more carbon intensive than the marginal source of energy generation being displaced. Marginal energy generation refers to plant which is most likely to be built or retired (or increase or decrease output) in response to policies resulting in long-term changes to electricity supply or demand.

The development of the CIF has assumed that energy generation from waste would be used to displace heat and power produced by more conventional forms of energy generation, i.e. electricity for homes and businesses and low-grade space heating. It has also been assumed that biofuels from waste would be used to displace carbon intense fossil fuels such as petrol and diesel. In 2008, decentralised energy accounted for just 2.5% of London's energy supply, the majority being mainly from gas (72.8%) and grid electricity (24.7%); the latter accounted for 50.4% of London's CO_2eq emissions by fuel source in the same year.

Displacing the Marginal Source of Energy

The approach to using the marginal source of energy generation as that which is most likely to be displaced is based on information taken from the DEFRA guidance document, Greenhouse Gas Policy Evaluation and Appraisal in Government Departments, published in April 2006 (IAG DEFRA Guidance).[44] This guidance has been produced by Government's Inter-Departmental Analysts Group (IAG) to provide a common approach to the evaluation and appraisal of GHG policy across Government departments. It is advised for use by Government departments, agencies and other bodies wishing to produce estimates of costs and benefits on a consistent basis. Given its intended purpose and audience, therefore, it should provide a sound basis upon which to base policy decisions related to the Mayor's EPS.

Combined Cycle Gas Turbine as the Marginal Source of Energy

The IAG DEFRA Guidance has been updated twice since 2006; the first update of the same title was published in December 2008 by DECC.[45] The second, Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation, was published by DECC in June 2010.[46] The latter is supported by a

[44] DEFRA (2006) Greenhouse Gas Policy Evaluation and Appraisal in Government Departments (c) Crown Copyright 2006.
[45] DECC (2008) Greenhouse Gas Policy Evaluation and Appraisal in Government Departments (c) Crown Copyright 2008.
[46] DECC (2010) Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation [online] available at http://www.decc.gov.uk/en/content/cms/statistics/analysts_group/analysts_group.aspx (accessed April 2011).

background information document that confirms CCGT as the marginal source of energy generation until at least 2025, after which the marginal plant is assumed to be a mix of low carbon generation technologies and CCGT plant, with the relative share of low carbon technologies in this mix increasing over time and the share of CCGT decreasing.[47]

DECC's consultation on electricity market reform notes that in order to cost-effectively meet the Government's 2050 emissions reductions target, the electricity sector will need to be largely decarbonised during the 2030s.[48] It assumes that the first type of plant likely to reduce output in response to alternative forms of energy generation coming on stream will be CCGT.

DECC's assumptions about the marginal source of energy generation are also supported by a Poyry report on the impact of wind generation on the British and Irish electricity markets. Figure 2, taken from the Poyry report, shows how running regimes for thermal plant may be altered in response to increasing quantities of wind generation in the market over time (alongside other forms of electricity generation).[49] The same report states that for CCGT particularly, plant availability will be reduced or require higher maintenance costs when faced with generation running regimes such as this and thus will become a marginal form of energy generation.

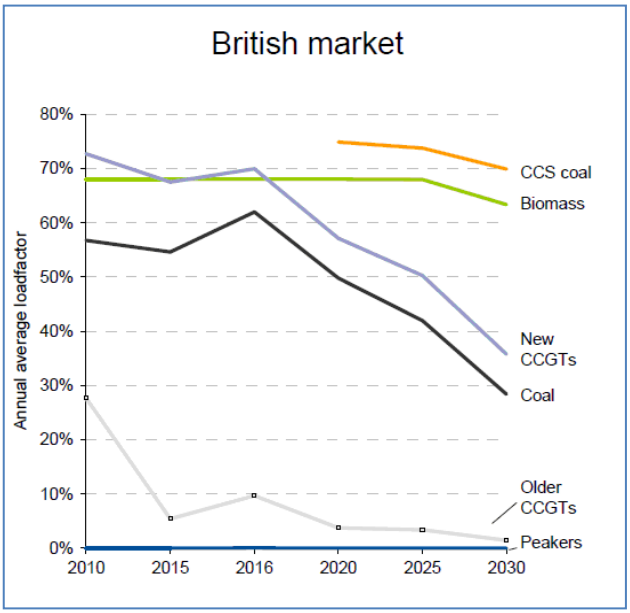

Figure 2: Annual Average Load Factors for Electricity Generation Plant

It appears correct to assume, therefore, that CCGT over time will no longer operate as the base load form of energy generation and will be the most likely

[47] DECC (2010) Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation: Background Information [online] available at http://www.decc.gov.uk/en/content/cms/statistics/analysts_group/analysts_group.aspx (accessed April 2011).
[48] Target to reduce emissions by 80% relative to 1990 levels by 2025.
[49] Poyry Energy (Oxford) Ltd (2009) Impact of Intermittency: How Wind Variability Could Change the Shape of the British and Irish Electricity Markets (Summary Report) July 2009 [online] available at http://www.poyry.com/linked/group/study (accessed March 2011).

form of power generation to be displaced by new waste to energy generation capacity in London

Alternative Approaches to Specifying a CIF Performance Level

It has been questioned during discussion with Government stakeholders and based on industry opinion whether the current specified performance level of 387kgCO_2/kWh is an appropriate level for the CIF and can be achieved technically and/or financially by the waste sector. Further discussion on this is contained within Section 4.2.2. This is particularly relevant given that CCGT is considered to be one of the most thermally efficient combustion technologies available for power generation, which might provide an unfair basis against which to compare waste to energy technologies.

It has been considered by the GLA whether an alternative approach to specifying a CIF should be used based instead on the use of average electricity emissions factors for electricity consumption (also known as system average values or grid mix carbon intensity).[50] Average electricity emissions factors accounts for the average CO_2eq emissions from the National Grid per kWh of electricity and so take account of all sources of energy generation.

The average electricity emission factor is currently around 452gCO_2/kWh which is higher than for marginal electricity generation (i.e. CCGT) due to the inclusion of more carbon intense coal power generation.[51] Whilst this might be considered an appropriate basis on which to specify a higher CIF performance level, DECC advises that average electricity emissions factors should only be used for reporting the level of emissions associated with electricity use as based on actual or predicted energy consumption. They are not considered appropriate by DECC to evaluate the impact that GHG policies might have on future emission levels.

Also, the average electricity emissions factor changes annually as the fuel mix consumed in UK power stations changes and DECC predicts that, over time this will reduce on a trajectory towards 200gCO_2/kWh (business as usual scenario) at 2030 due to less carbon intense forms of energy generation, such as nuclear and wind power coming on stream. Thus, average electricity emissions factors would also provide a less consistent benchmark on which to base the CIF over time (compared to the marginal electricity emissions factor for CCGT which is projected to remain constant at 393gCO_2/kWh until at least 2025).

DECC states that it will keep emissions factors for different fuel types under review and will update these as necessary as they are subject to considerable uncertainty in the long-term, particularly in the electricity sector where it is unclear what type or mix of generation will constitute future base load and marginal supply after 2025.[52] The use of marginal electricity emissions factors for

[50] For electricity supplied in the UK via the public distribution system, two different emissions factors are used: average electricity emissions factors for electricity consumption and marginal electricity savings emissions factors, used to evaluate the effectiveness of greenhouse gas policies.
[51] House of Commons Energy and Climate Change Committee (2010) Emissions Performance Standards: First Report of Session 2010-11, Volume I [online] available at http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/publications/ (accessed March 2011).
[52] DECC (2010) Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation [online] available at http://www.decc.gov.uk/en/content/cms/statistics/analysts_group/analysts_group.aspx (accessed April 2011).

the CIF should be kept under review as, beyond 2030, it is possible that the marginal source of energy generation displaced by a new waste to energy plant would be CCGT fitted with carbon capture and storage (CCS), although CCS is still an unproven technology at the current time. This could potentially reduce the average carbon intensity of CCGT to around 50-100gCO_2/kWh.[53] This implies that waste to energy plant might require the retrofit of CCS equipment although this is unlikely to be feasible for such types of facilities.

Consideration has also been given to whether there are existing mechanisms within the waste sector itself that could be used to achieve the same policy outcomes as the CIF. Annex II of the EU Waste Framework Directive, for example, specifies that the thermal treatment of municipal waste may be classed as a recovery operation (R1: use principally as a fuel or other means to generate energy) providing that 65% of the energy generated from the process is used (excluding parasitic load). This level of efficiency would typically require the use of heat generated, which could act as a driver to the use of combined heat and power (CHP) systems to provide decentralised and low carbon / renewable energy. There is no legislative requirement, however, for facilities to specifically meet this recovery standard (those that do not simply being classed as disposal operations). The R1 recovery standard also applies to individual facilities, whereas the CIF considers the carbon intensity of the energy generated from waste (which may be managed at more than one facility).

Recommendation 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 average electricity emissions.

4.1.2 Setting a Performance Level for the CIF

For the purpose of developing the Mayor's EPS, it has been assumed that CCGT has a carbon intensity of 387gCO_2/kWh of electricity produced. This figure, which has been used to set the performance level of the CIF, has been calculated by Eunomia on the basis of a modern CCGT power station with an assumed generation efficiency of 55% and calorific value of 39MJ/m³ for natural gas.

Background information to DECC's updated 2010 IAG guidance specifies a marginal electricity emission factor of 0.3939kgCO_2/kWh (or 393gCO_2/kWh) for CCGT up to 2025, which is higher than the current specified level of the CIF.[54] This is said to reflect DECC's current assessment of the emissions associated with electricity generation using CCGT. Marginal electricity emissions factors reflects the emissions of the marginal plant that is likely to be built or retired in response to policies resulting in long-term changes to electricity supply or demand. The marginal electricity emissions factor for CCGT would also appear suitable for use within the context of the CIF given that DECC advises the use of such factors to assess the impacts on CO_2eq emissions savings or increases that might occur as a result of GHG policy implementation.

Other research conducted during the course of this review also suggests that there are a higher range of values upon which the CIF could be based. Carbon intensity

[53] It is a planning condition that all new CCGT plant has to be capable of CCS retrofit.
[54] See page 9 of DECC's Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation: Background Information.

values for all types of power generation are highly variable and the electricity emissions value specified for an individual CCGT plant may be higher or lower than that specified by DECC. For example, variations in the carbon intensity level for CCGT may occur due to:

- Whether being considered as an annual emissions, lifetime or instantaneous emissions factor;
- Depending on the source of fuel use – for example, a Parsons Brinkerhoff report suggests a range of 320-380gCO_2/kWh for CCGT using UK natural gas and 340-410gCO_2/kWh for CCGT using imported liquid natural gas; and[55]
- The country in which the plant is operating – carbon intensity values for CCGT in other countries are reported as 450gCO_2/kWh (Sweden) and 472gCO_2/kWh (Finland).[56]

DECC has also reported difficulties in specifying a single performance level for the Government's EPS for power generation and, as part of the Government's consultation on energy market reform, has proposed two options on the level of the EPS to lessen the burden on the energy market.[57] Given that stakeholders have identified that the current specified level of the CIF might be challenging to achieve by the waste sector, it is recommended that the modelling work, being undertaken by others in parallel with this review, should be used to inform the specified performance level of the CIF such that it is set at a level which is both technically and financially achievable by the municipal waste sector. This would also help to ensure that London can meet its waste management needs as a primary concern.

Recommendation 16: The specified level of the CIF should be raised to at least 393gCO_2/kWh for consistency with DECC's latest IAG guidance. It is also recommended that the specified performance level of the CIF is reviewed 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.

4.2 Measuring Performance against the CIF

Performance against the CIF cannot be measured directly within WRATE but Eunomia has created a step-by-step methodology for doing so using data and assumptions contained within the WRATE model.[58] Although not currently contained within Appendix 4b to the Mayor's Draft MWMS, it is recommended to include this with a fully worked-through example to illustrate how performance against the CIF can be calculated should waste authorities wish to do so using information from WRATE. Reference should also be made to SLR's GHG

[55] Parsons Brinkerhoff (2009) Powering the Future: Mapping our Low-Carbon Path to 2050 (Full Report) [online] available at http://www.pbpoweringthefuture.com/ (accessed March 2011).
[56] European Union ExternE Project.
[57] DECC is proposing a level set either at 600gCO_2/kWh or 450gCO_2/kWh for plant operating at base load.
[58] This is because WRATE cannot provide the emissions associated with energy generation from a single plant; it only provides these results for LCA modelling (headline results).

calculator tool that will enable waste authorities to input municipal waste management and determine performance against the Mayor's EPS.

4.2.1 Scope of Emissions Considered

In measuring performance against the CIF, emissions are considered in terms of those associated with the generation of energy from local authority collected municipal waste only. The range of technologies that could be used to generate energy from waste and to which the CIF would apply is not defined in either the Mayor's Draft MWMS or Appendix 4b to the Mayor's Draft MWMS. However, discussions with the GLA reveal that it is likely that emissions from all types of technology used to generate energy from waste could be considered – with the exception of landfill gas capture and utilisation. The specific technologies considered by Eunomia in its initial modelling of the CIF include:

- Incineration (electricity only and CHP);
- Gasification / pyrolysis (electricity only and CHP); and
- Anaerobic digestion (use of biogas to generate heat and power).

Emissions associated with the following waste management activities are excluded for the purposes of meeting the CIF:

- Materials capture and subsequent reprocessing;
- Fuel preparation (MBT and autoclave);
- Reject streams sent to landfill; and
- Other landfill.

The CIF does not include emissions associated with fuel preparation or any subsequent landfill of materials arising from the process. In the case of fuel preparation, this approach is consistent with the scope of emissions considered by marginal and average electricity emissions factors for other forms of power generation. For example, marginal electricity emissions factors for gas and coal do not include emissions from the production or delivery of fuel to power stations (e.g. from gas rigs, refineries and collieries). All other emissions, such as those associated with landfill, for example, are addressed within the Whole Waste System EPS anyway.

Use of Biogas from Anaerobic Digestion

There appear to be inconsistencies between Appendix 4b of the Mayor's Draft MWMS and Policy 2 of the Mayor's Draft MWMS with respect to the interface between anaerobic digestion and the CIF. Policy 2 of the Mayor's Draft MWMS states that emissions associated with the use of biogas from anaerobic digestion can be used as part of a portfolio of waste to energy options to offset the performance of thermal waste to energy facilities treating more carbon intense residual waste feedstock. Thus, the net performance of all waste to energy facilities would be modelled to assess performance against the CIF.

Contrary to this policy position, Appendix 4b of the Mayor's Draft MWMS states there does not appear to be a sound evidence base for inclusion of anaerobic digestion within the scope of the CIF. Further to discussion with both Eunomia and the GLA on this point, it has been confirmed that anaerobic digestion will be

included in this way. Not only does this approach provide further flexibility for waste authorities to choose how to meet the specified CIF performance level but it is also in line with the GLA's policy stance to be technology-neutral and non-prescriptive in the way that the Mayor's EPS is to be met.

Recommendation 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.

The promotion of energy from waste using anaerobic digestion is a key feature of Government proposals being considered under its waste policy review. Anaerobic digestion is also considered within the scope of 'waste to energy' in the context of contributing to the Mayor's decentralised energy targets for London. Thus, whilst the GLA's decision to include anaerobic digestion within the scope of the CIF is supported, this should be made clear within all supporting documents to the Mayor's Draft MWMS.

Recommendation 18: Appendix 4b should be updated to make reference to the inclusion of anaerobic digestion within the scope of emissions to be measured against the CIF.

Use of Biogas from Landfill Gas Capture

Further to the inclusion of anaerobic digestion within the CIF definition of 'emissions associated with generation of energy from waste', it might also be considered as to whether landfill gas capture and utilisation might be included; for example, biogenic carbon emissions from landfill gas utilisation schemes in London (such as Beddington Landfill Power in Croydon) might be used to offset those of fossil carbon from other forms of waste to energy plant, in the same way that those from anaerobic digestion might be used. There is also still a role for landfill gas utilisation as a contributor to decentralised and renewable energy supply. For example, Table 5.1 of the Draft Consultation Replacement London Plan (installed energy capacity generated from renewables) includes landfill gas in addition to anaerobic digestion, gasification/pyrolysis and incineration plant.

On balance, Arup principally agrees with the GLA's conclusions not to consider landfill gas capture within the context of the CIF on the basis that it does not wish to encourage a perverse incentive for waste authorities to favour landfill gas capture with energy generation over other solutions. This would also be contrary to the Mayor's London Plan objective to work towards zero waste to landfill by 2031. It has been confirmed also that the CIF will only apply to new waste contracts, which are likely to involve the procurement of new waste infrastructure solutions by waste authorities for municipal waste management. It is, therefore, unlikely that there would be further reliance on sending untreated waste to landfill (emissions associated with reject material from fuel preparation, for example, are excluded).

Biogenic Carbon and Heat

Performance measurement against the CIF is in terms of the impacts associated with energy generated from the fossil carbon content within the waste, such as plastics for example, and emissions associated with the parasitic load of the facility. Emissions associated with the biogenic carbon (for example, those associated with food waste and paper/cardboard) content of the waste are zero rated and the benefits of heat production are taken into account.[59] This is consistent with the approach taken to residual waste thermal treatment in the Scottish Carbon Metric and EPE Protocol.

Transport Fuels

The scope of the CIF includes transport fuels where these are used to displace carbon intense fossil fuels such as petrol and diesel. It is assumed that authorities producing liquid or gaseous biofuels from waste will meet the CIF if there is a minimum of 50% biomass in feedstock sent for processing but no clear justification has been provided for this within Appendix 4b. On the basis of further discussion with Eunomia, it is understood that this level has been set in accordance with the 50% maximum level of the renewable energy content that can be declared by a generator to obtain Renewables Obligation Certificates (ROCs) from the Office of Gas and Electricity Markets (Ofgem) without any direct measurement to reflect a conservative estimate of the typical composition of municipal waste.[60]

Recommendation 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.

4.2.2 Achievability of the CIF

The ability to meet the CIF depends on three variables:

- Core generation technology employed (e.g. primarily considered in Eunomia's modelling as combustion or gasification, plus for the latter, whether this is steam turbine or gas engine);
- Biomass content of feedstock supply; and
- Whether feedstock is left untreated or processed into a solid recovered fuel (SRF) before being processed in a waste to energy facility.

Eunomia has undertaken some indicative modelling to assess under what circumstances the CIF might be met when varying these three factors. WRATE

[59] Heat produced is assumed to displace domestic gas boilers (conventional boilers with 87% thermal efficiency) for domestic dwellings (space heating and hot water). Assumed that heat is re-circulated in periods of no/low heat demand which increases % electrical efficiency. Annual load factor of 60% assumed.

[60] Ofgem can award ROCs on up to 50% of the total energy content of MSW fuel stream to operators that satisfy evidential requirements without necessarily having to directly measure the renewable energy content of the waste. Where an operator wishes to claim ROCs on more than 50% of the total energy content of the waste fuel stream, they may need to directly measure the renewable energy content of the waste.

has been used to create a series of technology user-defined process to facilitate this process as follows:

- Incineration (electricity only and CHP);
- Gasification with steam turbine (electricity only and CHP); and
- Gasification with gas engine (electricity only and CHP).[61]

The results of this work are presented in Table 3.1 and Table 3.2 of Appendix 4b to the Mayor's Draft MWMS (see Appendix A10).

Biomass Content

The modelling undertaken by Eunomia indicates that a high proportion of the calorific value of both untreated waste and SRF is required to come from biomass in order to meet the CIF. Generally, this figure is above 50% but varies according to the generation technology employed, the nature of the feedstock (untreated municipal waste or SRF) and the assumed energy generation efficiency of a waste to energy facility. As stated above, Ofgem assumes that waste contains 50% biomass in the absence of any direct measurement data. However, the Renewable Energy Directive states a value of 62.5% and recent, as yet unpublished research by DEFRA, indicates that this might be as high as 68%. There is a risk that the biomass content of untreated municipal waste and/or SRF may drop over time as, for example, more paper, cardboard, kitchen and food wastes are recovered through materials recycling and reprocessing. However, reprocessing does also include use of anaerobic digestion technology which, as outlined, in Section 4.2.1, could be used to offset the emissions associated with generation of energy from fossil carbon in other types of waste to energy plant.

Table 3.3 of Appendix 4b to the Mayor's Draft MWMS (see Appendix A11) shows that as recycling and composting rates increases, the calorific value of residual waste that is derived from biomass decreases. The biomass content may be refined either through the front-end removal for recycling of high embodied carbon materials such as plastics. Alternatively, it might be necessary for waste authorities to pre-treat residual waste to refine inputs using MBT and/or require CHP to meet the CIF. However, using MBT solutions to refine and improve the biomass content of SRF may result in higher reject rates with material subsequently being disposed to landfill. The implications of removing biomass content from the residual waste fraction to meet recycling and composting targets is discussed further in Section 6.

Use of Combined Heat and Power

There are two waste to energy facilities operating in the Greater London regional area:

- Edmonton Energy Centre, operated by London Waste Ltd in the London Borough of Enfield; and
- South East London Combined Heat and Power (SELCHP), operated by Veolia Environmental Services in the London Borough of Lewisham.

[61] Each WRATE scenario models one tonne of default waste composition (DEFRA 2007 municipal waste composition for England) using an electricity mix based on 100% CCGT with an efficiency of 47.6%.

Neither facility is currently producing combined heat and power and, although the SELCHP facility is CHP enabled, district heating arrangements have never been realised to date. A third facility, the Riverside Resource Recovery Facility at Belvedere in the London Borough of Bexley, is still being commissioned by Cory Environmental Ltd and will eventually process waste from the Western Riverside Waste Authority and City of London. The plant is CHP-enabled but an outlet is still required for the heat output. A report commissioned by Cory Environmental Ltd reports that the density of heat consumers in the local area is much lower than is typical for district heating schemes in the UK.[62]

This illustrates the complexities in finding and connecting to suitable heat outlets even though there does not appear to be any difficulties in constructing waste to energy facilities that are CHP-enabled. In line with the London Plan objective to manage as much of London's waste within London as practicable, consideration should be given to the availability of local heat markets and issues around site selection and the planning regime for waste to energy facilities to connect to proposed or existing heat networks.

These issues are being addressed to an extent through the delivery of two key programmes, which have been developed to help facilitate the delivery of large-scale CHP systems within London. These are:

- **Decentralised Energy Masterplanning Programme (DEMaP):** a resource developed to help facilitate and accelerate delivery of decentralised energy projects across London. Its purpose is to help London boroughs and the commercial sector to develop energy masterplans that can be used to identify opportunities and develop the business case on which deliverable projects can be funded.
- **London Heat Map:** an online, geographic information system (GIS)-based system that allows users to identify opportunities for decentralised energy projects in London. The system provides spatial intelligence to help relevant to the identification and development of decentralised energy opportunities including energy consumers, existing community heating networks and energy demand density.

Biossence Limited, which is currently developing a CHP-enabled gasification facility (the East London Sustainable Energy Facility in Dagenham, East London) is currently looking at opportunities to sell heat to the proposed London Thames Gateway Heat Network in Dagenham. The plant will process 98,000 tonnes per year of SRF under a long-term fuel supply contract from the nearby Frog Island and Jenkins Lane MBT plants operated by Shanks East London, using residual municipal waste provided by East London Waste Authority. The plant will generate 18-20MW of electrical power and around 10MW of thermal power, with the electricity being exported to the National Grid via a connection to the local EDF distribution network.[63]

Thus, the DEMaP and London Heat Network programmes have the potential to support the selection of appropriate waste to energy sites in London although no assessment has been made of their effectiveness to date.[64]

[62] Based on research conducted by PB Power and reported at http://www.coryenvironmental.co.uk/page/rrrcasestudy6.htm.
[63] http://www.sustainablelondon.co.uk/new/facility.php
[64] Also not considered within the scope of this review.

5 Other Findings

5.1 Definition of Municipal Solid Waste

The definition of waste used in the context of the Mayor's EPS is local authority collected municipal solid waste. A decision was taken by the EPS Steering Group not to use the new definition of municipal solid waste as data on other wastes outside of the current scope is not sufficiently reliable. However, the GLA considers that should this data improve, there may be a case in the future to expand the scope of the Mayor's EPS to other wastes.

5.2 Review Cycle and Data Quality

The Mayor's Draft MWMS states that the Mayor is required to keep his MWMS under review and will publish an annual monitoring report on the progress of his polices and proposals. The Mayor's Draft MWMS further states that London's performance against the Mayor's EPS will be monitored and reported annually. However, there is no specific reference to a periodic review cycle having been established to reassess the scope, methodology and assumptions used within the Mayor's EPS in the future. Ongoing review will be required given the horizon of the Mayor's policy objective and targets to 2031. DECC plans to review its EPS on a three-year cycle (next review due end 2012) and the Scottish Carbon Metric has specified a five-year review cycle.

Recommendation 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.

5.3 Presentation of Methodology and Terminology

It is not immediately clear, from either the Mayor's Draft MWMS or Appendix 4b to the Mayor's Draft MWMS, that the Whole Waste System EPS and CIF are designed to be met simultaneously although it has been confirmed through further discussion with the GLA that waste authorities would need to meet the performance levels for both constituent parts together.

Recommendation 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.

Consistency is also required with respect to the use of terminology and EPS metrics used throughout Appendix 4b to the Mayor's Draft MWMS. For example, the Whole Waste System EPS is sometimes also referred to as the Core EPS. A small number of inconsistencies were also found with respect to the use of metrics for both the Whole Waste System EPS and CIF; for example:

- Page 7 refers to a Whole Waste System EPS of -0.3kgCO_2/tonne in 2015 but it has been confirmed that the EPS should be -0.3tCO_2/tonne for that year.
- Page 15 refers to a CIF of 387gCO_2/kWh but then goes on to state that performance must be expressed as kgCO_2/kWh. Again, it has been confirmed that the performance level of the CIF should be expressed as gCO_2/kWh.

Recommendation 22: To avoid any confusion, Appendix 4b of the Mayor's Draft MWMS should be revised to ensure that consistent terminology and metrics are used with respect to both the Whole Waste System EPS and CIF.

5.4 Intended Audience of the Mayor's EPS

It is assumed that the intended audience of the Mayor's EPS is Joint and Unitary Waste Disposal Authorities although this is not explicitly stated in either the Mayor's Draft MWMS or Appendix 4b to the Mayor's Draft MWMS. There also needs to be further clarity on the requirements of Waste Collection Authorities with respect to the need for developing waste collection strategies that enable both parts of the Mayor's EPS to be met.

Recommendation 23: Clarity should be provided as to those organisations that are directly and indirectly affected by the Mayor's EPS.

5.5 Application of the Mayor's EPS

It has been confirmed that there will not be any retrospective application of the Mayor's EPS to existing contracts, such that a grandfathering rule will be applied.[65] This means that existing contracts would be exempt from the need to comply with the Mayor's EPS. This would appear to be a sensible approach, particularly with respect to the CIF where some waste authorities have recently entered into long-term contracts for the treatment and disposal of residual waste using methods that may not enable the specified performance level to be met. This is consistent with the approach being used by Government, for example, with the EPS, which will apply only to new power stations on the date of consent.

It is not clear, however, either within Policy 2 of the Mayor's Draft MWMS or Appendix 4b to the Mayor's Draft MWMS, whether the performance levels specified by each constituent part of the Mayor's EPS are intended as benchmarks or a required standard that must be met by waste authorities. Furthermore, the consequences of not meeting the Mayor's EPS do not appear to have been communicated to the intended audience.

Recommendation 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).[66]

[65] Grandfathering is a term used to describe a situation in which an old rule continues to apply to some existing situations, while a new rule will apply to all future situations.
[66] The Whole Waste System EPS changes on a trajectory over time according to the projected quantities of municipal waste required to be managed in the future at 2015, 2020 and 2031.

6 Policy Considerations

6.1 Emissions Reduction Targets

Emissions reductions targets for London are set out in the Mayor's Draft Climate Change Mitigation and Energy Strategy and are shown in Table 3 below, alongside those set nationally within the UK and for European Member States. These are emissions reductions required against 1990 baseline levels.

Table 3: CO_2eq Emissions Reduction Targets

Year	Greater London	United Kingdom[67]	European Union[68]
2015	20%	28%	-
2020	38%	34%	20%
2025	60%	-	-
2030	-	-	-
2050	80%	80%	-

In terms of contribution to energy policy, only the CIF is relevant to emissions reductions targets for London, which cover only direct (Scope 1) and indirect (Scope 2) emissions of carbon dioxide associated with energy generation.[69] The CIF would only contribute to these targets in the sense that the emissions associated with the generation of energy from waste should be no more carbon polluting than the marginal source of energy being displaced, i.e. should limit any potential increase in emissions. However, it is not possible to comment on the level of this contribution of CIF to reducing emissions from energy from waste since this has yet to be determined by the GLA. Consequently, it is also not possible to comment on its contribution to national and European targets for emissions reductions.

The Mayor's emissions reduction targets do not include 'Scope 3' emissions, which would include those associated with waste management activities other than the generation of energy from waste (e.g. emissions savings that might occur through changes to waste-related transportation and non-energy generating activities). Emissions from sectors including agriculture, waste, industrial processes and international transport are currently outside of the scope of emissions reductions required to meet the UK's target as shown in Table 3. However, Government's 2050 Pathway Analysis, which examines different scenarios for meeting these targets, concludes overall that reductions in emissions from waste (and other sectors) will be necessary by 2050.[70] Thus, the Whole Waste System EPS would appear to be an effective driver for London's municipal waste management to become a net reducer of CO_2eq emissions, potentially

[67] UK Climate Change Act 2008 requires a reduction in GHG emissions of 34% by 2020 and 80% by 2050, relative to 1990 baseline levels.
[68] European Union 20-20-20 Commitment requires 20% renewable energy supply by 2020, a 20% reduction in GHG emissions relative to 1990 baseline and 20% less energy consumption.
[69] According to the Mayor's Draft Climate Change Mitigation and Energy Strategy, Scope 1 emissions are those associated with the direct combustion of energy and Scope 2 emissions are those associated with the generation of purchased electricity.
[70] HM Government (July 2010) 2050 Pathway Analysis (c) Crown Copyright 2010.

contributing further to the Mayor's emissions reduction targets for London should Scope 3 emissions be included at a future point in time.[71]

6.2 Decentralised and Renewable Energy Supply

Decentralised and Renewable Energy Supply in London

Delivery of decentralised energy is a key policy objective of Mayor's Climate Change Mitigation and Energy Strategy, within which he has set a target for 25% of London's energy to be generated from decentralised sources by 2025 (equivalent to around 23TWh).[72]

Decentralised energy is defined by the Mayor's Draft Climate Change Mitigation and Energy Strategy as the provision of low carbon and renewable heat and power generation within London. Thus, the contribution of London's municipal waste to supplying decentralised energy would be the same as that for low carbon and renewable energy supply.

Table 4 shows that, in 2025, London will require an energy supply equivalent to 91TWh net of anticipated energy efficiency measures. Of this amount required, 25% (23TWh) is expected to come from decentralised sources of energy, of which 23% (5.3TWh – or 6% of London's overall energy supply) is expected to be provided by London's energy from waste.[73]

Table 4: Estimated Energy Supply Required for London in 2025

	Estimated Supply Required	Proportion of London's Energy Supply	Proportion of Decentralised Supply
London's Energy Supply	91TWh	-	-
Decentralised Energy Supply	23TWh	25%	-
Waste to Energy Supply	5.3TWh	6%	23%

Waste to energy in this context refers to all types of waste management technologies that have the potential to generate heat and power and transport fuel. This includes waste to energy technologies, such as anaerobic digestion, gasification/pyrolysis, incineration and landfill gas. The contribution of each type of waste to energy technology is shown in Table 5.1 of the Draft Consultation Replacement London Plan (installed energy capacity generated from renewables) (see Appendix A12). It has been confirmed by the GLA that waste to energy in this context also includes that which would be generated from commercial and industrial waste. The GLA has commissioned a further study to assess and update

[71] Based on the associated emissions calculated under the Whole Waste System EPS (see Appendix A8), the GLA estimates net GHG emission savings from municipal waste management for each of the three target years as follows: 1.2mtCO_2/annum in 2015; 1.4mtCO_2/annum in 2020; and 1.6mtCO_2/annum in 2031.

[72] Greater London Authority (2010) Delivering London's Energy Future: The Mayor's Draft Climate Change and Energy Strategy for Public Consultation [online] available at http://www.london.gov.uk/priorities/environment/climate-change/climate-change-mitigation-strategy (accessed March 2011).

[73] Personal Communication with GLA Climate Change Mitigation and Energy Team, March 2011.

the potential for decentralised energy generation in London, which will be used to update the energy supply data in the Mayor's Climate Change Mitigation and Energy Strategy.[74] It has not been possible to determine (within the scope of this review) the exact nature of the contribution of the CIF to decentralised energy supply within London. This is because:

- The scope of waste to energy facilities considered within the scope of decentralised energy provision is greater than that covered by the CIF (e.g. landfill gas capture is included);
- The 23% contribution of waste to energy shown in Table 4 includes all waste, from both municipal, and commercial and industrial sources, whereas the CIF covers just municipal waste; and
- The CIF applies to the emissions associated with the energy generated from waste regardless of the location of the facility. Not only is this potentially at odds with the London Plan objective to manage as much of London's waste within London as practicable, but the potential to generate energy from London's municipal waste within London may not actually be realised. However, there are potentially greater opportunities within London for the establishment of CHP networks that might be required for waste authorities to meet the CIF. It is also anticipated that the recommendation to include waste-related transport impacts within the scope of the Whole Waste System EPS (see Recommendation 8 in Section 3.2.4) would act as a further incentive to reduce emissions from waste-related transport and manage as much of London's waste within London as practicable.

Renewable Energy Supply Policy in the European Union and UK

The European Union's Renewable Energy Directive stipulates a target to achieve 20% of energy and 10% of transport fuels from renewable sources by 2020. Within the UK, the Renewables Obligation (RO) is the main support scheme for renewable electricity generation projects in the UK. It places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources, including the biomass content of municipal waste.

Renewables Obligation Certificates (ROCs) are issued to accredited generators for each megawatt hour (MWh) of electricity generated from renewable fuels (such as the biomass content of waste) and supplied to customers within the UK. The RO Scheme currently provides support for both renewable electricity and 'good quality renewable heat' from CHP, although consideration is being given to transferring support for heat generation from the RO to the Renewable Heat Incentive (RHI). Generation of heat from the biomass content of waste would be eligible for support under the RHI as electricity production would be under the RO Scheme.[75] The future of support mechanisms for renewable heat will take

[74] Due for release in June 2011. The review will be consistent with the DECC Renewable and Low Carbon Energy Capacity Methodology for assessing opportunities and constraints for deployment of renewable and low-carbon energy deployment. It will make recommendations for updated targets for installed energy capacity and energy delivered from renewable and low carbon sources for the London region and quantify the potential for large-scale renewable deployment in London by the installation of heat networks.

[75] Eligible waste feedstock for combustion, gasification and pyrolysis will be limited to solid biomass from municipal waste including SRF. Tariffs will also apply to heat generated by the combustion of biogas from AD.

place within the current RO Banding Review, with any changes due to come into effect in 2013.[76]

Thus, the RO and/or RHI would provide an incentive to the production of a high biomass content feedstock for the generation of energy from waste and use of CHP, which as shown by Eunomia's indicative modelling, would be likely to meet the CIF. Alternatively, the use of biogas from anaerobic digestion to generate heat and power would also qualify for support under the RO and RHI. The likely contribution of London's municipal waste to meeting UK and European Union targets for renewable energy generation is currently unknown but will be dependent on the amount of biomass within the feedstock being used for energy generation purposes.

6.3 Recycling and Composting Targets

Recycling and composting targets applicable to municipal waste management in London are shown in Table 1 (see Section 1.3).

The Whole Waste System EPS has been modelled by Eunomia on the basis of collection and treatment scenarios that would meet the Mayor's recycling and composting targets for 2015, 2020 and 2031. Eunomia states that it should be possible to simultaneously meet the Whole Waste System EPS level and the Mayor's recycling and composting targets on the basis that the bulk of emissions reductions required to meet the Whole Waste System EPS must be delivered by materials recycling and reprocessing. It is reasonable to assume, therefore, that if waste authorities are theoretically able to meet both the Whole Waste System EPS alongside specified recycling and composting targets for London then, by default, they should meet those set by the Waste Strategy for England 2007 and EU Waste Framework Directive. However, it is likely that authorities would be required to collect a mix of high embodied carbon materials (such as plastics and non-ferrous metals) and heavier materials (such as glass) to meet the specified EPS level alongside recycling and composting targets.

Eunomia's modelling has shown that a system focused on collection of high embodied carbon materials would meet the Whole Waste System EPS levels but not necessarily weight-based targets. This would also lessen the fossil carbon content of the residual waste being used to generate energy, making the CIF potentially easier to achieve. This could enable both the Whole Waste System EPS and CIF to be met together but not necessarily weight-based targets for recycling and composting.

To date, Eunomia's modelling has focused on the modelling of the Whole Waste System EPS and CIF in isolation of each other. It is unclear at this stage, therefore, as to whether both constituent parts of the Mayor's EPS can be met together and in conjunction with weight-based recycling and composting targets. Furthermore, which types of waste management scenario would be preferable for meeting all three requirements and whether this is achievable both technically and financially. For example, as biomass content is potentially drawn out for recycling and reprocessing, the biomass content of the residual waste would decrease. Conversely, production of a high-biomass residual fraction to meet the

[76] DECC (2011) Renewable Heat Incentive [online] available at http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/policy/incentive/incentive.aspx (accessed April 2011).

CIF would potentially impact on meeting weight-based targets, particularly with respect to meeting the Mayor's recycling and composting target for 2031 (60%) although this is 'aspirational' and not set as a target nationally or by the EU Waste Framework Directive.

DEFRA's Waste Policy Unit has confirmed that it supports the approach of the Mayor's EPS to achieve the best environmental outcomes (in carbon terms) provided that weight-based recycling and composting targets are not compromised; furthermore that it is likely to be complimentary to reforms that may be implemented as a result of the forthcoming Waste Policy Review for England.[77]

It is therefore essential that the Mayor's EPS is compatible with weight-based recycling and composting targets for 2015 and 2020, which align with those set nationally for England and by the European Union. However, the target for London to achieve 60% recycling and composting by 2031 is an 'aspirational' one, downward revision of which would lead to a less stringent Whole Waste System EPS requirement for that year and provide greater flexibility in meeting both the CIF and Mayor's recycling and composting targets.

It is not known whether a 60% recycling and composting target will be set by Government. However, it is understood from discussions with DEFRA (conducted as part of this review) that the Waste Policy Review for England will signal the future development of a carbon metric for waste management activities. However, DEFRA may not yet go as far as the Mayor in determining how such a metric would be developed and on what basis it would apply to different types of waste management activities. To this end, the Mayor's EPS is ahead of national waste policy but mindful of the need to comply with existing national and European weight-based recycling and composting targets.

[77] Personal Communication with DEFRA Waste Policy Unit, March 2011.

7 Conclusions

7.1 Scope and Purpose of Review

Arup has reviewed the scope, methodology and detailed assumptions used for developing the Mayor's EPS, the purpose of which is to achieve the best environmental outcomes (in carbon terms) for the management of London's municipal waste. A series of 24 recommendations have been made, summarised in Section 8, which will be considered by the GLA for immediate or future action in terms of further refining the Mayor's EPS. In some case, the recommendations make reference to the additional modelling work that has been undertaken by SLR in parallel with this review. The outcomes of both pieces of work should, therefore, be considered together to further develop the Mayor's EPS.

7.2 Strategic Considerations

At a strategic level, the Mayor's policy objective to develop an EPS for municipal waste management is consistent with, if not ahead of, emerging national waste policy. DEFRA's waste policy unit, for example, has indicated that it will be considering the development of a carbon metric to be implemented nationally alongside recycling and composting targets. The challenge for waste authorities, however, will be in meeting the specified performance levels of the Mayor's EPS (both Whole Waste System EPS and CIF) alongside statutory recycling and composting targets for 2015 and 2020 (and the Mayor's aspirational target to achieve 60% recycling and composting for 2031). To date, it does not appear that any modelling has been undertaken to demonstrate how all three components can be achieved in a way that is both technically and financially achievable, although it is likely that this will be informed further by the outcomes of SLR's additional work.

In terms of contribution to energy policy, the CIF will be the main contributor with respect to provision of decentralised and renewable energy supply. It should also help to limit any potential increase in emissions relative to the source of energy being displaced with that from waste to energy facilities. However, it has not been possible to determine exactly the degree of contribution to relevant energy policy and targets within the scope of this particular review. Emissions reductions that would be achieved by the Whole Waste System EPS are not currently considered within the scope of emissions reductions for London but have the potential to make a contribution to these targets in the future nonetheless.

7.3 Methodology, Scope and Assumptions

Overall, the methodology used for developing each constituent part of the Mayor's EPS appears fit for purpose given the availability of information and tools available to help determine greenhouse gas emissions from waste management activities. However, some further refinement of the scope and methodological approach used is required to ensure that the Mayor's EPS is both technically and financially achievable by London's waste authorities.

7.3.1 Whole Waste System EPS

A life-cycle assessment approach for the development of the Whole Waste System EPS is similar to other methods that have been developed to quantify emissions from waste management activities, namely the WRATE model itself and the Scottish Carbon Metric, which also uses WRATE. The key recommendations made are in relation to the scope of emissions considered within the life cycle assessment (LCA) approach that has been used to specify the performance levels of the Whole Waste System EPS.

The GLA's decision to include re-use activities as a waste management option as and when suitable emissions factor data becomes available is supported provided that consideration is given to the system boundaries of the LCA studies used to provide the information required. This would enable waste authorities to benefit from the avoided emissions of re-use activities within the scope of meeting the Whole Waste System EPS performance levels.

It is also recommended that emissions from waste-related transportation should be included such that waste authorities can benefit from the potential emissions reductions associated with methods of rail and river transportation. Furthermore, than an approach similar to that used within the Scottish Carbon Metric or Protocol for the Quantification of Greenhouse Gas Emissions from Waste Management Activities (EPE Protocol) should be used facilitate the inclusion of waste-related transport emissions, which are currently a notable exclusion from the LCA approach used.

It is not possible to states what effect the inclusion of re-use and waste-related transport emissions might have on the existing performance levels specified for the Whole Waste System without further modelling being undertaken. At the very least, however, it should provide waste authorities with further flexibility in how to meet the Whole Waste System EPS performance levels. It should also incentivise waste authorities to implement re-use activities as a preferred waste management option and to reduce emissions associated with waste-related transportation.

7.3.2 Carbon Intensity Floor for Energy Generation

The marginal emissions approach used to determine the specified performance level of the CIF would appear to be suitable based on the fact that CCGT (as the marginal source of energy generation) is that most likely to be displaced by London's waste to energy facilities until at least 2025.[78] The current specified performance level of the CIF is 387kgCO_2/kWh, which has been calculated by Eunomia on the basis of a modern CCGT power station with an assumed generation efficiency of 55% and calorific value of 39MJ/m³ for natural gas. However, it is recommended that the level of the CIF be raised to at least 393kgCO_2/kWh in line with latest guidance from the Department of Energy and Climate Change, which specifies this as a marginal electricity emissions factor for

[78] Marginal energy generation refers to plant which is most likely to be built or retired (or increase or decrease output) in response to policies resulting in long-term changes to electricity supply or demand.

CCGT.[79] It is also recommended that further modelling work, being undertaken by others in parallel with this review, should also be used to inform the specified performance level of the CIF such that it is set at a level which is both technically and financially achievable by the municipal waste sector, given other constraints, such as issues around site selection and planning permission for new waste to energy facilities in London. This would also help to ensure that London can meet its waste management needs as a primary concern with the needs of emissions reductions and decentralised and renewable energy being a secondary consideration to this. However, a decision by the GLA to allow waste authorities to offset emissions from energy generation (from technologies such as gasification and incineration) with those associated with use of biogas from anaerobic digestion will also provide further flexibility for waste authorities to decide how best to meet the specified performance level alongside the Whole Waste System EPS and recycling and composting targets.

[79] DECC (2010) Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation [online] available at http://www.decc.gov.uk/en/content/cms/statistics/analysts_group/analysts_group.aspx (accessed April 2011).

8 Summary of Recommendations

8.1 Whole Waste System EPS

8.1.1 Methodology

Economic Modelling (Capture Rates Information)

- **Recommendation 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.

Whole Waste System EPS Performance Level

- **Recommendation 2:** It has been confirmed the Whole Waste System EPS is based on the associated emissions for Scenario One ('Focus on Dry and Low Biomass New Technologies) as shown in Appendix 4b to the Mayor's Draft MWMS. However, this should be stated explicitly within Appendix 4b to the Mayor' Draft MWMS.

8.1.2 Scope of Associated Emissions

Re-Use

- **Recommendation 3:** As a waste management option, re-use should be included within the scope of associated emissions for the Whole Waste System EPS.
- **Recommendation 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.
- **Recommendation 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.

Incinerator Bottom Ash and Reject Material from MRF and MBT

- **Recommendation 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.

Transport

- **Recommendation 7:** The statement that waste-related transport emissions typically account for a small percentage (5% to 10%) of the total CO_2eq emissions from waste management activities should be verified for London.
- **Recommendation 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.

Modelling Waste-Related Transport Emissions

- **Recommendation 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.

8.1.3 Calculating Associated Emissions

Peer Review of WRATE UDPs

- **Recommendation 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.

Emissions Factors for Recycling and Reprocessing

- **Recommendation 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.
- **Recommendation 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 Draft MWMS.
- **Recommendation 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 for Residual Waste Management

- **Recommendation 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 can be replicated to verify the performance levels of the Whole Waste System EPS for the baseline and target years.

8.2 Carbon Intensity Floor

8.2.1 Methodology

Approach to Specifying a CIF

- **Recommendation 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.

Setting a Performance Level for the CIF

- **Recommendation 16:** The specified level of the CIF should be raised to at least 393gCO_2/kWh for consistency with DECC's latest IAG guidance. It is also recommended that the specified performance level of the CIF is reviewed 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.

Scope of Emissions Considered

- **Recommendation 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.
- **Recommendation 18:** Appendix 4b should be updated to make reference to the inclusion of anaerobic digestion within the scope of emissions to be measured against the CIF.
- **Recommendation 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.

8.3 Other Findings

8.3.1 Review Cycle and Data Quality

- **Recommendation 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.

8.3.2 Presentation of Methodology and Terminology

- **Recommendation 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.
- **Recommendation 22:** To avoid any confusion, Appendix 4b of the Mayor's Draft MWMS should be revised to ensure that consistent terminology and metrics are used with respect to both the Whole Waste System EPS and CIF.

8.3.3 Audience

- **Recommendation 23:** Clarity should be provided as to those organisations that are directly and indirectly affected by the Mayor's EPS.

8.3.4 Application of the Mayor's EPS

- **Recommendation 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).[80]

[80] The Whole Waste System EPS changes on a trajectory over time according to the projected quantities of municipal waste required to be managed in the future at 2015, 2020 and 2031.

Appendix A

A1 Public Consultation Responses

In October 2010, the Mayor of London published his draft Municipal Waste Management Strategy (MWMS) for public and stakeholder consultation. During the 14 week consultation exercise, which closed on 14 January 2011, a total of 135 responses were received. Stakeholder responses were received from:

- Government organisations;
- London waste authorities;
- Waste Industry; and
- Other (including third sector and non-waste industry) companies.

Responses concerned with the Mayor's EPS (as outlined in Policy 2 of the Mayor's Draft MWMS) showed that:

- There is support for a focus on climate change mitigation from the waste sector, not weight based targets;
- There is support for a non-prescriptive approach to the Mayor's EPS;
- More clarity is required as to how the Mayor's EPS works and will be enforced and monitored;
- More evidence is required to demonstrate how the Mayor's EPS supports EU policy;
- The Mayor's EPS should be advisory not mandatory;
- Information is required in relation to costs of meeting carbon intensity floor for energy generation;
- There is a need to assess how the methodology for the Mayor's EPS compares to similar tools, such as the Protocol for the Quantification of Greenhouse Gas Emissions from Waste Management Activities (EPE Protocol); and
- There is a need to assess how the Mayor's EPS might incorporate reuse and reduction activities.

Responses concerned with the Mayor's recycling and composting targets (as outlined in Policy 2 of the Mayor's Draft MWMS) that are relevant in the context of the Mayor's EPS are as follows:

- Recycling and composting targets are thought to be too ambitious for London's circumstances; and
- The need for recycling and composting targets was questioned if now moving towards implementation of the Mayor's EPS.

A2 Scottish Carbon Metric

Purpose

The Carbon Metric Reporting System for Recycling Performance (Scottish Carbon Metric) has been developed by Zero Waste Scotland and the Scottish Government as a tool to help prioritise waste policy options and promote a reduction in the environment impact of resource use.

Scope

The following emissions are included for measurement within the scope of the Scottish Carbon Metric:

- Emissions associated with energy inputs for extraction of raw materials;
- Emissions associated with energy inputs for product processing and manufacture;
- Emissions associated with transportation of waste; and
- Direct emissions of all waste management treatment and disposal processes (reuse, recycling, composting, anaerobic digestion, mechanical biological treatment, waste to energy processes and landfill), although note that data for reuse options is currently limited and has been highlighted as an area for further review.

Performance Monitoring

Monitoring of waste management performance in Scotland will now take into account environmental impact (through the Carbon Metric) alongside Scotland's existing weight-based target to achieve 70% recycling, composting and preparing for re-use of all waste by 2025.

Waste authorities in Scotland will not be required to calculate performance on an individual basis but municipal waste management data (submitted as part of Waste Data Flow requirements) will be used centrally to monitor the carbon impact of alternative forms of waste management options being used.

This information will be used by the Scottish Government to help inform policy around the preferred waste management option for specific products and materials based on environmental impact and considered in conjunction with weight-based tonnage data.

In theory, the Scottish Carbon Metric is designed to apply to all waste streams but considers only municipal waste at present due to the need for more detailed and accurate data in other areas.

Toolkit

Zero Waste Scotland and the Scottish Government have developed a toolkit for use, which includes:

- Technical Report;[81]
- Carbon Trust Peer Review Report;[82]
- Carbon Factors Spreadsheet;[83]
- Carbon Metric Guidance;[84] and
- Carbon Metric Calculator.[85]

Overall, the Carbon Trust Peer Review Report concluded that 'the Carbon Metric provides a clear methodology to define and monitor recycling targets with reference to their environmental impact'. Furthermore, that it 'complements the current weight-based targets, providing a better steer and incentives to chose the most appropriate waste management techniques available for each material'.

Further information about the Scottish Carbon Metric is available at http://www.zerowastescotland.org.uk/carbon_metric/carbon_metric.html.

[81] Zero Waste Scotland (2011) Final Report: The Scottish Carbon Metric [online] available at http://www.zerowastescotland.org.uk/carbon_metric/carbon_metric.html (accessed March 2011).
[82] Carbon Trust Advisory Services (2011) Review of Methodology for the Carbon Metric for Scotland (Final Report) [online] available at http://www.zerowastescotland.org.uk/carbon_metric/carbon_metric.html (accessed March 2011).
[83] Zero Waste Scotland (2011) The Carbon Factors for Waste Streams and Waste Management Technologies in the Scottish Carbon Metric [online] available at http://www.zerowastescotland.org.uk/carbon_metric/carbon_metric.html (accessed March 2011).
[84] The Scottish Government (2011) Scotland's Zero Waste Plan: Carbon Metric Guidance [online] available at http://www.scotland.gov.uk/Publications/2011/03/14151422/2 (accessed March 2011).
[85] The Scottish Government (2011) Carbon Metric Calculator [online] available at http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Waste-1/CarbonMetricCalculator (March 2011).

A3 EPE Protocol

Purpose

The Protocol for the Quantification of Greenhouse Gases Emissions from Waste Management Activities (EPE Protocol) has been developed by *Enterprise Pour L'Environnement* (EPE) in conjunction with a number of waste sector industry partners (Suez Environment, Seche Environment and Veolia Environmental Services).

The development of the EPE Protocol is based on the expectation that, whilst not included within the scope of the EU Emissions Trading Scheme (EU ETS), the waste sector will need to demonstrate emissions savings through appropriate waste management options.

The purpose of the EPE Protocol is, therefore, to provide a global and common method to enable both companies and local authorities to conduct annual inventories of greenhouse gas emissions from their waste management activities.

EPE is seeking the support of national waste management associations and the endorsement of World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI) for the Protocol to become the key sectoral document linked to the Greenhouse Gas Protocol established by WBCSD and WRI to standardise the reporting process for GHG emissions.

Scope

The scope of the EPE Protocol considers:

- Emissions associated with transportation of waste; and
- Emissions associated with all forms of waste management treatment and disposal processes (recycling, composting, anaerobic digestion, mechanical-biological treatment, waste to energy processes and landfill).

Performance Monitoring

The EPE Protocol is intended as a tool that can be used by companies and local authorities to report greenhouse gas emissions associated with waste management activities on a voluntary basis. It will also provide the ability for those organisations to compare alternative waste management options from an environmental impact perspective, rather than on the basis of performance against weight-based targets.

Toolkit

The EPE Protocol toolkit consists of:

- Protocol for the Quantification of Greenhouse Gases Emissions from Waste Management Activities (Version 4, June 2010);
- Excel Tool for the Calculation of Emissions from Different Waste Activities (Version 4, June 2010);
- Frequently Asked Questions Document; and

- Summary of Follow-Up Modifications (from Version 3, December 2008, to Version 4, June 2010).

Further information about the EPE Protocol is available at:

- http://www.epe-asso.org/; and
- http://www.epe-asso.org/index_en.php?part=publi&id_rap=20.

A4 Scottish Carbon Metric: Waste-Related Transport Information

Table 4.2 Distances used in calculation of the Carbon Metric

Destination / Intermediate Destination	One Way Distance	Mode of transport	Source
Household, commercial and industrial landfill	25km by Road	26 Tonne Refuse Collection Vehicle, maximum capacity 12 tonnes	WRATE (2005)
Inert landfill	10km by Road		WRATE (2005)
Transfer station / CA site	10km by Road		
MRF	25km by Road		
MSW incinerator	50km by Road		
Cement kiln	50km by Road		
Paper and Card	41% 250km by Road, 59% 250km by road, 18000km by Boat to Guangdong, 50km by road	Average, all HGVs	WRAP (2008)[22]
Glass (Container – Clear and Amber)	50km by Road		WRATE (2005)
Glass (Container Green) 24% total	50km by road and 390km by Boat		WRAP
Glass – construction aggregate	50km by Road		WRATE (2005)
Aluminium	50% 250km by Road, 50% 50km by road and 390km by Boat	Average, all HGVs, 5000-10,000 TEU capacity vessel. For China, the vehicle is assumed to be 32 tonne vehicle meeting Euro II emissions criteria	WRAP estimate based on Hull – Rotterdam
Steel/Iron	34% 250km by Road, 66% 50km by road and 390km by Boat		
Plastics	33% 250km by Road, 67% 250km by road, mixed plastics 17600km by Boat to Hong Kong, PET 19000km by Boat to Shanghai, HDPE 18000km by Boat to Tianjin, then 150km by road (80km for mixed plastic)		WRAP (2008)
Wood	50km by Road	Average, all HGVs	WRATE (2005)
Inert recycling	10km by Road		WRATE (2005)

Source: The Scottish Carbon Metric.[86]

[86] Zero Waste Scotland (2011) Final Report: The Scottish Carbon Metric [online] available at http://www.zerowastescotland.org.uk/carbon_metric/carbon_metric.html (accessed March 2011).

A5 Emissions Reduction Factors for Materials Recycling and Reprocessing

Table 2-2: Emissions Reduction Factors for Materials Recycling (WRATE)

Material	Impact of Activity (kgCO2/tonne of waste managed)		
	Recycling ('closed loop')	Anaerobic digestion (electricity only)	Composting
Paper and card	-299	n/a	n/a
Food waste	n/a	-82.9	-47[1]
Garden waste	n/a	n/a	-41.7[2]
Wood	0.968	n/a	n/a
Textiles	-4,372	n/a	n/a
Plastic (dense)	-1,182	n/a	n/a
Metals (ferrous)	-1,623	n/a	n/a
Metals (non-ferrous)	-10,721	n/a	n/a
Glass	-169	n/a	n/a
Aggregate materials	21	n/a	n/a

Notes:
1. In-vessel composting (IVC)
2. Open-windrow composting (OWC)

Source: Appendix 4b to the Mayor's Draft MWMS.[87]

[87] Eunomia Research & Consulting Limited (2010) Development of a Greenhouse Gas Emissions Performance Standard for London's Municipal Waste: The Greater London Authority [online] available at http://www.london.gov.uk/consultation/waste-strategy (accessed March 2010).

A6 Emissions Factors for Residual Waste

Table 14: WRATE Emissions Factors (kg CO2e / tonne)

Material	Incineration		Gasification (Gas Engine)		Gasification (Steam Turbine)		Landfill
	Electricity only	CHP	Electricity only	CHP	Electricity only	CHP	
Paper and card	-295	-420	-432	-547	-247	-335	399
Food waste	-34	-70	-99	-132	-63	-71	291
Garden waste	-57	-101	-129	-170	-86	-95	291
Wood	-447	-623	-627	-791	-455	-491	1,116[1]
Textiles	352	203	198	59	345	314	209
Plastic (dense)	1,255	1,037	1,043	840	1,256	1,213	11
Plastic (film)	1,147	925	936	730	1,154	1,109	4.52
Metals (ferrous)	n/a	n/a	n/a	n/a	n/a	n/a	2.59
Metals (non-ferrous)	n/a	n/a	n/a	n/a	n/a	n/a	4.33
Glass	32	18	-17	-30	-3	-6	2.59
Aggregate materials	257	230	216	191	242	236	3.17

Notes:

1. 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 as it is what remains in the current version of WRATE

Source: Appendix 4b to the Mayor's Draft MWMS.[88]

[88] Eunomia Research & Consulting Limited (2010) Development of a Greenhouse Gas Emissions Performance Standard for London's Municipal Waste: The Greater London Authority [online] available at http://www.london.gov.uk/consultation/waste-strategy (accessed March 2010).

A7 Baseline Emissions for Waste Management in London 2008/09

Table 2-1: Baseline Emissions from Waste Management in London (2008)

Waste Management Activity	Waste Managed (ktpa)[1]	Associated Emissions (ktCO2e)
Residual Waste		
Landfill	1,830	466.77
MBT	278	1.31
Incineration	838	8.88
Organic waste		
Anaerobic Digestion	4	-0.37
In-vessel Composting	124	-5.81
Open Air Windrow Composting	143	1.40
Materials Recycling / Reprocessing		
Paper / Card	385	-115.18
Glass	62	-10.51
Metals (ferrous)	49	-135.00
Metals (non-ferrous)	13	-28.86
Plastics	24	-52.63
Textiles	12	0.03
Wood	33	0
TOTAL	3,797	130.05

Notes:

1. Excluded from this analysis are 10ktpa of waste which were sent for reuse, and a further 176ktpa which represent rejects streams from Material Recovery Facilities (MRFs) and Mechanical Biological Treatment (MBT) facilities, along with incinerator bottom ash. These have not been included in the model as their composition, and thus impact in landfill, cannot be modeled accurately in WRATE. If these streams were included, total waste managed in London would be 3,955ktpa, which is consistent with related Defra figures

Source: Appendix 4b to the Mayor's Draft MWMS.[89]

[89] Eunomia Research & Consulting Limited (2010) Development of a Greenhouse Gas Emissions Performance Standard for London's Municipal Waste: The Greater London Authority [online] available at http://www.london.gov.uk/consultation/waste-strategy (accessed March 2010).

A8 Projected Emissions for Waste Management in London at 2015, 2020 and 2031

Table 2-3: Total Emissions associated with meeting the EPS for London

Waste Management Activity	Waste Managed (ktpa)			Associated Emissions (ktCO2e)		
	2015	2020	2031	2015	2020	2031
Residual Waste[1]						
Landfill	300	150	0	75.3	36.2	0
Incineration	1,318	1,318	788[2]	-27.3	-8.7	28.6
Incineration (bio-drying)	167	82[3]	107	9.3	4.9	11.2
Gasification - Steam Turbine (bio-drying)	111	82[3]	107	16.7	13.9	23.8
Gasification - Gas Engine (bio-drying)	0	41	321	-	-2.8	-8.7
Organic waste						
AD	126	157	205	-10.5	-13.1	-17.0
IVC	247	278	329	-11.6	-13.1	-15.4
OAW	199	213	277	1.9	2.1	2.7
Materials Recycling / Reprocessing						
Paper / Card	713	780	905	-213.1	-233.1	-270.6
Glass	107	110	128	-18.2	-18.6	-21.7
Metals (ferrous)	138	153	184	-223.8	-247.9	-298.7
Metals (non-ferrous)	59	65	79	-633.4	-701.8	-845.7
Plastics	65	76	97	-76.8	-89.7	-115.1
Textiles	15	18	22	-64.6	-79.6	-98.3
Wood	42	44	58	0	0	0.1
TOTAL	3,885	3,845	3,875	-1,176	-1,351	-1,624
EPS (tCO2/t)				-0.303	-0.351	-0.419

Notes:

1. The EPS is set at the level of the *lowest* performing of the six key scenarios, and therefore not all residual technologies, for example, autoclaving, which are employed in the wider modelling, are included here
2. It is assumed that Edmonton closes between 2015 and 2020
3. The fall in tonnage gasified is due to the increasing tonnage of materials recycled to meet the 2020 target, which could result in over-capacity of residual treatment infrastructure

Source: Appendix 4b to the Mayor's Draft MWMS.[90]

[90] Eunomia Research & Consulting Limited (2010) Development of a Greenhouse Gas Emissions Performance Standard for London's Municipal Waste: The Greater London Authority [online] available at http://www.london.gov.uk/consultation/waste-strategy (accessed March 2010).

A9 Associated Emissions for Baseline Year (2008/09)

2008 Baseline		Data from Table 2.1		Updated Table 2.1 (Figures from Eunomia)	Data from Table 2.2	Arup Cross-Check (Using Updated Table 2.1 Data)
Waste Stream	**Waste Management Activity**	**Waste Managed (ktpa)**	**Associated Emissions (ktCO2)**	**Associated Emissions (ktCO2)**	**Emission Factors (kgCO2/tonne)**	**Associated Emissions (ktCO2)**
Residual Waste	Landfill	1,830	466.77	466.77	255.07	466.77
	MBT	278	1.31	1.31	4.71	1.31
	Incineration	838	8.88	8.88	10.60	8.88
Organic Waste	AD	4	-0.37	-0.37	-82.9	-0.33
	IVC	124	-5.81	-5.81	-47	-5.83
	Open Windrow	143	1.40	1.40	-41.7	-5.96
Materials Recycling	Paper/Card	385	-115.18	-115.18	-299	-115.12
	Glass	62	-10.51	-10.51	-169	-10.48
	Ferrous Metals	49	-135.00	-80.3	-1,623	-79.53
	Non-Ferrous Metals	13	-28.86	-135	-10,721	-139.37
	Plastics	24	-52.63	-28.86	-1,182	-28.37
	Textiles	12	0.03	-52.63	-4,372	-52.46
	Wood	33	0	0	0.968	0.03
TOTAL		**3,795**	**130.03**	**49.70**	**-**	**39.54**
TOTAL (tCO2)		**-**	**130,030**	**49,700**	**-**	**39,544**
TOTAL (tonnes waste)		**3,795,000**	**-**	**-**	**-**	**-**
EPS (tCO2/tonne waste)		**-**	0.03	0.01		0.01

Figures provided to Arup by Eunomia in updated report

Emission factor back-calculated from assumed associated emissions

Assumed that figures are correct, cannot verify

Discrepancies between Eunomia and Arup Calculations

A10 Indicative Modelling for the CIF

Table 3-1: Indicative Requirements for achieving the Carbon Intensity 'Floor'

Technology	Mode of operation	Assumed Generation Efficiency (%)[1]		CV from Biomass (%)[3]	
		Electricity	Heat[2]	Untreated waste	SRF
Incineration	Electricity only	28%	n/a	71%	68%
	Electricity only	21%	n/a	80%	78%
	CHP	19%	30%	58%	55%
Gasification (steam turbine)	Electricity only	25%	n/a	79%	76%
	CHP	17%	27%	64%	61%
Gasification (gas engine)	Electricity only	33%	n/a	65%	63%
	CHP	33%	24%	43%	41%

Notes:
1. Generation efficiencies for gasification take into account the losses that occur during the conversion of the energy contained within the waste to syngas
2. Generation efficiencies for heat assume a load factor (i.e. the proportion of heat generated that is used) of 60%
3. Values for SRF are calculated in WRATE on a dry matter basis, whereas those for untreated wastes are calculated on a fresh matter basis (i.e., including the impact of the moisture content)

Table 3-2: Further Example Scenarios modelled against the Carbon Intensity 'Floor'

Technology	Fuel type	Mode of operation	Assumed Generation Efficiency (%)[1]		CV from Biomass (%)[3]	Meets Energy EPS?
			Elec.	Heat[2]		
Incineration	SRF	Elec only	29%	n/a	66%	yes
	SRF	Elec only	24%	n/a	68%	no
	Untreated wastes	CHP	20%	26%	60%	yes
	Untreated wastes	CHP	18%	33%	55%	no
Gasification Steam turbine	SRF	Elec only	23%	n/a	76%	yes
	SRF	Elec only	25%	n/a	72%	no
	SRF	CHP	18%	23%	64%	yes
	SRF	CHP	16%	30%	60%	no
Gasification Gas engine	SRF	Elec only	32%	n/a	65%	yes
	SRF	Elec only	37%	n/a	55%	no

Notes:
1. Generation efficiencies for gasification take into account the losses that occur during the conversion of the energy contained within the waste to syngas
2. Generation efficiencies for heat assume a load factor (i.e. the proportion of heat generated that is used) of 60%
3. Values for RDF are calculated in WRATE on a dry matter basis, whereas those for untreated wastes are calculated on a fresh matter basis (i.e., including the impact of the moisture content)

Source: Appendix 4b to the Mayor's Draft MWMS.[91]

[91] Eunomia Research & Consulting Limited (2010) Development of a Greenhouse Gas Emissions Performance Standard for London's Municipal Waste: The Greater London Authority [online] available at http://www.london.gov.uk/consultation/waste-strategy (accessed March 2010).

A11 Biomass Content within Residual Waste Stream at Varying of Recycling and Composting

Table 3-3: Biomass potentially within Residual Waste Streams

Assumed Recycling / Composting Rate[1]	CV from Biomass of Residual Waste (%)[2 3]
25%	62%
45%	60%
50%	53%
60%	49%

Notes:

1. All assumptions for capture rates of different materials are based on information published by WRAP (2009). A maximum of 15% of the total recycling / composting rate is derived from food waste collection
2. It should be noted that these levels of biomass are indicative only. Waste authorities might focus on different materials to achieve the same levels of recycling, which would result in different levels of biomass in the residual composition
3. The composition of the residual waste modelled under each recycling / composting rate is provided in Appendix 5

Source: Appendix 4b to the Mayor's Draft MWMS.[92]

[92] Eunomia Research & Consulting Limited (2010) Development of a Greenhouse Gas Emissions Performance Standard for London's Municipal Waste: The Greater London Authority [online] available at http://www.london.gov.uk/consultation/waste-strategy (accessed March 2010).

A12 Targets for Installed Energy Capacity Generated from Renewables

Energy Source	2015				2020				2025			
	Energy Capacity		Energy Output		Energy Capacity		Energy Output		Energy Capacity		Energy Output	
	Electricity/ MWe	Heat/ MWth	Electricity/ GWh	Heat/ GWh	Electricity/ MWe	Heat/ MWth	Electricity/ GWh	Heat/ GWh	Electricity/ MWe	Heat/ MWth	Electricity/ GWh	Heat/ GWh
Stand Alone Wind	18		33		25		47		29		54	
Microwind	2		3		6		7		12		14	
Biomass Heat – building integrated		67		117		94		165		120		210
Biomass Heat – large scale		67		245		134		489		200		730
Biomass Heat and Power – small scale (up to 5MWe)	5	20	35	105	16	65	114	342	15	45	105	237
Biomass Heat and Power – large scale (>5MWe)	68	146	500	1,097	102	219	750	1,645	136	292	1,000	2,194
Air Source Heat Pump (ASHP) – microgeneration		30		76		165		413		550		1,375
Ground Source Heat Pump (GSHP) – microgeneration		2		6		3		7		6		14
Large Scale GSHP		9		17		23		46		49		99
Photovoltaics	12		10		68		54		317		285	
Solar Thermal		25		20		39		30		67		53
Anaerobic Digestion	6.3	38	33	29	7.5	11	67	58	8.9	16	115	100
Gasification/Pyrolysis	73.5	353	460	600	94.6	137	663	865	121.7	199	1,140	1,488
Sewage Treatment	45.0	60	125	200	50.0	80	150	250	60.0	100	200	300
Landfill Gas	7.0		25.0		7.0		25.0		7.00		25.00	
Biodegradable element of incineration plant					97	291	491	1,473	97	291	491	1,473
Total	**237**	**817**	**1,223**	**2,511**	**474**	**1,260**	**2,368**	**5,783**	**804**	**1,935**	**3,430**	**8,272**

Source: Draft Consultation London Plan.[93]

[93] Greater London Authority (2010) The London Plan: Spatial Development Strategy for Greater London (Consultation Draft Replacement Plan, October 2009) [online] available at http://www.london.gov.uk/shaping-london/london-plan/strategy/download.jsp (accessed March 2010).