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Climate Change Impacts of Residual Waste Treatment

Report for UKWIN

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Report for:

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Disclaimer

1.0 Introduction

The United Kingdom without Incineration Network (UKWIN) is an independent organisation representing a network of groups opposing the expansion of waste incineration in the UK. One of the stated aims of the organisation is to promote sustainable waste management. The Network therefore has a general interest in the production and dissemination of reliable information on the sustainability and environmental impact of different waste management options, with the aim of informing relevant strategies, policies, plans and planning application decisions at both a local and national level.

Incineration is widely considered to offer a more environmentally friendly solution to waste disposal via landfill, as it is felt to result in the emission of fewer greenhouse gases – a view held by many both inside and outside of the waste management industry. UKWIN has commissioned Eunomia Research & Consulting to undertake an independent comparative investigation with a view to testing the validity of this assertion, and to report specifically in respect of an incinerator proposed for the Battlefield site at Shrewsbury in Shropshire.

This short report therefore considers the climate change impacts of landfilling or incinerating residual waste in the Shropshire region. Comparisons are made between 90,000 tonnes of waste sent to incinerator and landfill over a 20 year period. Since landfill emissions continue to occur for some time after this period, total impacts are also considered over a 150 year period. The impacts are considered using Eunomia's proprietary model Atropos, which has been used in recent policy projects undertaken on behalf of the Irish Government, the Committee on Climate Change, Defra and the devolved administrations, the Renewable Fuels Agency and the European Commission. Results from the current analysis are compared with those previously obtained in an earlier study carried out by RPS on behalf of Veolia in support of their proposed incineration facility at Battlefield.[1]

The report begins, in Section 2.0, with a summary of the key assumptions used in the analysis, whilst results are presented in Section 3.0.

2.0 Assumptions

2.1 General

Key general assumptions that apply to both treatment technologies include the following:

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[1] RPS (2009) Carbon Analysis Final Report: Battlefield Energy From Waste Facility, Shropshire, Report for Veolia, November 2009

- The modelling has been undertaken using two residual waste compositions:
  - In the central case, we use the recent analysis undertaken by MEL for the Bishops Castle area of Shropshire; [2]
  - Sensitivity analysis considers results obtained with the composition used in the previously published Carbon Analysis undertaken by RPS on behalf of Veolia.[3]

  The first of these is taken to be reasonably representative of a Local Authority residual waste composition, given the current rate of recycling in the Shropshire area which reached 50% in November 2010.[4] As recycling rates improve, this tends to concentrate the plastic material in the residual stream as these materials are less well captured by recycling schemes such that the proportion of plastic may exceed 15% of the total residual stream in some cases (this is particularly the case when food waste collection services are introduced).[5] In contrast, the composition used by RPS in their earlier analysis assumed a plastic content of 7%.
- We assume that the marginal source of electricity is gas generated at a CCGT facility with a carbon intensity of 0.39 kg CO_2 per kWh, in line with UK Government Guidance in this area.[6]

A key issue in the assessment of GHG emissions from waste treatment technologies is whether or not non-fossil CO_2 (otherwise known as biogenic CO_2) should be included.

Under international GHG accounting methods developed by the Intergovernmental Panel on Climate Change (IPCC), biogenic or non-fossil CO_2 is considered to be part of the natural carbon balance and therefore not a contributor to atmospheric concentrations of CO_2.[7] National inventories deal with changes in fluxes of non-fossil

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[2] MEL Research Ltd (2010) Bishops Castle Residual Waste Composition Analysis, Final Report, February 2010

[3] RPS (2009) Carbon Analysis Final Report: Battlefield Energy From Waste Facility, Shropshire, Report for Veolia, November 2009

[4] Recycling rates are typically higher in wealthier areas. The MEL analysis suggests that Bishops Castle – with 57% of the population in ACORN group "Affluent Achievers" (compared to a national average of 23%) - is such an area. However, recycling rates across the whole district are expected to rise during the 20 year period of the contract, as existing services are improved. As such, the composition is felt to be reasonably representative of the area as a whole over the 20 year period being considered in this analysis.

[5] The plastics content in the Bishops Castle waste composition is 11%

[6] This differs from RPS assumption of where the value of 0.53 kg CO_2/kWh electricity supplied was used, although the authors also applied the long term projected emissions factor of 0.43 kg CO_2/kWh as sensitivity. Eunomia's assumption is taken from the toolkit published by DECC / HMT in association with the report: DECC / HMT (2010) Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation, June 2010

[7] Intergovernmental Panel on Climate Change (1997) *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3, Pg. 6.28

CO_2 through accounting for changes in land use and the ability of land to act as a sink or source of CO_2. The rationale behind the IPCC's decision is that non-fossil carbon was originally removed from the atmosphere via photosynthesis, and under natural conditions, it would eventually cycle back to the atmosphere as CO_2 due to degradation processes. Climate change, however, is attributed to anthropogenic emissions, which impact the natural carbon cycle.

As regards waste, the Guidelines from IPCC state that the following should be reported: [8]

> *Total emissions from solid waste disposal on land, wastewater, waste incineration and any other waste management activity. Any CO_2 emissions from fossil-based products (incineration or decomposition) should be accounted for here but see note on double counting under Section 2 "Reporting the National Inventory." CO_2 from organic waste handling and decay should not be included.*

Specifically regarding waste incineration, the same guidelines state that reporting should include:

> *Incineration of waste, not including waste-to-energy facilities. Emissions from waste burnt for energy are reported under the Energy Module, 1 A. Emissions from burning of agricultural wastes should be reported under Section 4. All non-CO_2 greenhouse gases from incineration should be reported here as well as CO_2 from non-biological waste.*

Given the above, then it is worth reporting what is set out regarding energy. The following are to be reported:

> *Total emissions of all greenhouse gases from all fuel combustion activities as described further below. CO_2 emissions from combustion of biomass fuels are not included in totals for the energy sector. They may not be net emissions if the biomass is sustainably produced. If biomass is harvested at an unsustainable rate (that is, faster than annual re-growth), net CO_2 emissions will appear as a loss of biomass stocks in the Land-Use Change and Forestry module. Other greenhouse gases from biomass fuel combustion are considered net emissions and are reported under Energy. (Sum of I A 1 to I A 5). Incineration of waste for waste-to-energy facilities should be reported here and not under Section 6C. Emissions based upon fuel for use on ships or aircraft engaged in international transport (1 A 3 a i and 1 A 3 d i) should, as far as possible, not be included in national totals but reported separately.*

Methane (CH_4) is also derived primarily from non-fossil carbon during degradation processes. However, CH_4 emissions from landfills are counted within GHG inventories. The rationale provided by the IPCC can be described as follows:[9]

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[8] Understanding the Common Reporting Framework, in IPCC (u.d.) Revised 1996 IPCC Reporting Guidelines for National Greenhouse Gas Inventories, Reporting Instructions (Volume 1), Hadley Centre, Bracknell

> *CH_4 emissions from landfills are counted - even though the source of carbon is primarily biogenic, CH_4 would not be emitted were it not for the human activity of landfilling the waste, which creates anaerobic conditions conducive to CH_4 formation.*

Currently, the convention in life cycle analysis appears to be shaped by IPCC's approach to dealing with non-fossil carbon in the reporting of Greenhouse Gas Inventories by different countries.

The crucial point here is that for the purposes of IPCC reporting, biogenic CO_2 from incineration and thermal treatment of waste is effectively not included. Although it could be argued that this convention of ignoring non-fossil CO_2 is appropriate within the inventory context, it has perhaps erroneously been applied to comparative assessments between waste management processes.

The need to include biogenic CO_2 has been recognised for a number of years by some of those involved in life-cycle assessments, such as Finnveden *et al*[10]. More recently, others have similarly taken the view that the biogenic CO_2 emissions should be included when accounting for the climate change impacts of biomass energy generation and waste management facilities. These include Rabl et al, who discussed the issue in an article in the International Journal of Life cycle assessment:[11]

> *In a part of the LCA community, a special convention has been established according to which CO_2 emissions need not be counted if emitted by biomass. For example, many studies on waste incineration do not take into account CO_2 from biomass within the incinerated waste, arguing that the creation of biomass has removed as much CO_2 as is emitted during its combustion.*
>
> *The logic of such a practice would imply absurd conclusions, e.g. that the CO_2 emitted by burning a tropical forest, if not counted, would equalize the climate impact of burning a forest and preserving it, which is obviously wrong. Likewise, the benefit of adding carbon capture and sequestration (CCS) to a biomass fuelled power plant would not be evaluated because that CO_2 is totally omitted from the analysis……..*

The article advocates the inclusion of the biogenic CO_2 emissions at each step of the analysis:

> *……By explicitly counting CO_2 at each stage, the analysis is consistent with the 'polluter pays' principle and the Kyoto rules which imply that each greenhouse*

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[9] USEPA (2004) *Greenhouse Gas Emission Factors for Municipal Waste Combustion and Other Practices*

[10] G. Finnveden, J. Johansson, P. Lind and A. Moberg (2000) *Life Cycle Assessments of Energy from Solid Waste*, FMS: Stockholm

[11] Rabl A (2007) How to Account for CO_2 Emissions from Biomass in an LCA, *International Journal of Life Cycle Assessment*, 12, pp281; Searchinger D, Hamburg S, Melilo J, Chameides W, Havlik P, Kannen D, Likens G, Lubowski R, Obersteiner M, Oppenheimer M, Robertson G, Schlesinger W. See also: Tilman D (2009) Fixing a Critical Climate Accounting Error, *Science*, 326, pp527-528

gas contribution (positive or negative) should be allocated to the causing agent.

The issue was also discussed at the first conference for users of the Environment Agency's life cycle tool WRATE held in November 2009, during which it was confirmed that the inclusion of biogenic CO_2 emissions within the calculation of the Global Warming Potential would be considered in future versions of the tool.

The current study therefore presents the results both inclusive and exclusive of the biogenic CO_2 emissions. We believe the inclusion of these emissions provides a more accurate analysis of the climate change impact. However we also present the results of the analysis exclusive of the biogenic CO_2 emissions in order to allow the results of the assessment to be viewed in the context of both the majority of literature published in this field, and in the wider policy environment.

2.2 Landfill

Key assumptions that remain the same throughout both the central case and the sensitivity analysis include the following:

- 50% of landfill gas is CH_4 (the remainder being biogenic CO_2);
- A further 10% of the CH_4 in the landfill gas is assumed to be oxidised to CO_2 in the landfill cover layer;[12]
- Where landfill is captured, the generation of electricity is assumed, using a gas engine with an electrical efficiency of 37.5%;
- The method for modelling the rate of methane generation and the proportion of carbon degraded follows the recommendations made to Defra regarding improvements that might be made to the UK's current model for estimating landfill impacts as part of the country's annual inventory submission to the IPCC.[13] These assumptions result in approximately 50% of the biogenic carbon contained within the residual waste stream being degraded over a 150 year period.

A key area of contention is the proportion of landfill gas that is assumed to be captured. The literature on this subject has been reviewed elsewhere by Eunomia and others.[14] In the central case for the current analysis we assume a landfill gas capture of 50%, whilst sensitivity analysis considers results with 20% gas capture, the default assumption indicated in the 2006 Guidance published by the IPCC.[15]

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[12] Note that this was not considered in RPS's Carbon Analysis

[13] Eunomia (2010) Inventory Improvement Project – UK Landfill Methane Emissions Model, Final Report to Defra, November 2010

[14] See, for example, Eunomia (2010) Landfill Bans: Feasibility Research, Final Report to WRAP, February 2010

[15] IPCC (2006) IPCC Guidelines for National Greenhouse Gas Inventories: Chapter 3 – Solid Waste Disposal

2.3 Incineration

Key assumptions used to model the incinerator include the following:

- The plant is assumed to generate only electricity with a gross electrical efficiency of 23%;
- Energy requirements of the plant are assumed to be 82 kWh electricity and 2.3 kg diesel per tonne of waste to the plant;
- 50% of ferrous metal is assumed to be removed for recycling.

Energy generation and consumption assumptions are based on information supplied by Veolia.

Our assumptions regarding the carbon content of the waste materials and their calorific values are presented in Table 1.

Table 1: Carbon Contents and Energy Content of Materials in the Waste Stream

	Total C (% fm)	Proportion of C that is non fossil	Energy content (lower heating value as received) MJ per kg	Typical moisture content
Paper	32%	100%	13	15%
Card	32%	100%	13	20%
Dense plastic	69%		36	10%
Plastic film	70%		34	13%
Textiles	30%	50%	15	20%
Glass	0%		0	2%
Ferrous metal	0%		0	3%
Non ferrous metal	0%		0	5%
Wood	32%	100%	15	30%
Garden waste	18%	100%	7	55%
Food waste	13%	100%	4	70%
Misc. combustible	17%	50%	14	20%
Misc. non-combustible	0%		0	12%

3.0 Results

3.1 Central Case

Table 2 presents the emissions impacts from 90,000 tonnes of waste treated annually at each type of facility for 20 years. Since landfill emissions continue to occur for some time after this period, total impacts are also considered over a 150 year period. These results show that when impacts excluding the biogenic CO_2 emissions are considered, incineration performs better than landfill. Where, however, the totals include biogenic CO_2, landfill performs better than incineration over both the 20-year and 150-year time periods.

Table 2: Total Emissions from Landfilling and Incineration

	Totals excluding biogenic CO_2		Totals including biogenic CO_2	
	Landfill	Incineration	Landfill	Incineration
20 year total	331,778	259,462	447,514	841,868
150 year total	482,867	259,462	710,879	841,868

Notes

Totals assume 90,000 tonnes of residual waste is treated annually for 20 years.

Table 3 provides a breakdown of the results from one year's worth of impacts, presenting emissions from 90,000 tonnes of waste (with impacts calculated over 150 years in the case of landfill). The table includes an estimation of impacts associated with transport taken from RPS (2009). The Table confirms that where biogenic CO_2 emissions are excluded, landfill performs worse than incineration. Where they are included, however, impacts associated with incineration are greater than that of landfill.

Table 3: Breakdown of Emissions Impacts (from 90,000 tonnes of Residual Waste)

	Emissions, tonnes CO_2 equivalent	
	Landfill	Incineration
Process emissions excluding biogenic CO_2	25,758	33,643
Process emissions including biogenic CO_2	37,158	62,763
Emissions offsets	-1,615	-20,670
Transport	6,868	5,363
Totals excluding biogenic CO_2	31,011	18,336
Totals including biogenic CO_2	42,412	47,456

Notes

The Table provides the impacts from landfilling or incinerating 90,000 tonnes of waste with impacts calculated using Eunomia's model (but assuming the same residual waste composition as was the case in the RPS analysis). In the case of landfill, calculations give the impact of each tonne over a 150 year time period.

Emissions offsets include the generation of electricity from both facilities (in the case of landfill this results from the combustion of captured landfill gas) and from the recycling of ferrous metal at the incinerator.

Indicative transport impacts are taken from RPS (2009).

Even where biogenic CO_2 emissions are included, total process emissions for landfill as shown in Table 3 are considerably less than those calculated by RPS in their Carbon Analysis report for Veolia. The report by RPS confirms they assume:

- A much higher biogenic carbon content in the waste - 213 kg per tonne of waste compared to Eunomia's assumption of 88 kg. This differential relates to both differences in composition modelled (results with the same composition are presented in Section 3.2 of this report), and a higher biogenic carbon content for certain waste fractions such as putrescible materials and miscellaneous combustibles;
- A smaller proportion of the total biogenic carbon is degradable (32% compared to Eunomia's assumption of 50%).

In addition, RPS did not consider the oxidation of CH_4 in landfill gas by microbes within the landfill cover layer.[16] The analysis by RPS further suggests a much higher emissions offset associated with the generation of electricity from landfill gas.[17]

Process emissions excluding biogenic CO_2 impacts are higher in Eunomia's analysis of the incineration impacts when compared to that produced by RPS as a result of the higher fossil carbon content of the residual waste stream. Avoided emissions are more significant for incineration in the RPS analysis as a result of the greater carbon intensity assumed for electricity generation leading to a greater benefit in this regard (0.53 kg CO_2 equivalent per kWh for RPS compared to 0.39 kg per kWh in the current analysis).

The combustion of waste such as occurs in an incinerator results in an instantaneous release of CO_2 emissions. In contrast, impacts associated with landfill result in emissions impacts occurring more slowly over a much longer time period. Figure 1 and Figure 2 show the annual emissions impact over the 20 year period equating to the lifetime of the incinerator contract both inclusive and exclusive of the biogenic CO_2 emissions. In the case of the landfill emissions, the cumulative emissions are shown such that year 2 also includes the continuing emissions impact associated with the material landfilled in year 1. Thus, whilst annual impacts from the incinerator remain constant throughout the 20 year period, the impacts associated with landfill increase over time.

Where biogenic CO_2 emissions are excluded, although impacts associated with landfill are initially less than that of incineration, the cumulative impact of previous years landfilling is such that the annual impacts become more significant in year 6. Where, however, biogenic CO_2 emissions are included, annual impacts associated with incineration are more significant than that of landfill in each year of the 20 year time period. The model suggests that at the end of the 20 year period, 20% of the total carbon contained within the waste stream will have been emitted.

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[16] The current analysis assumes an oxidation rate of 10%

[17] This offset appears to be unrealistically high for the amount of degradable carbon in question, even given the greater carbon intensity associated with the marginal source of electricity generation

It should be noted that impacts associated with landfill will also continue beyond the 20 year time frame considered in these two graphs, as was indicated in the results presented in Table 2. Even at the end of the 150 year period, however, over 70% of the total carbon (both fossil and biogenic) contained within the waste stream will remain un-emitted.

3.2 Composition Sensitivity

Results in this section consider the impacts using the waste composition used by RPS in their earlier analysis undertaken on behalf of Veolia. In this case, the composition has a lower proportion of plastic material and a much lower proportion of miscellaneous non-combustible material than that used in the central case. Total impacts are shown in Table 4. The results indicate that where impacts including biogenic CO_2 emissions are considered over a 150 year period, the total impact from landfill is greater than that of incineration.

Table 4: Total Emissions from Landfilling and Incineration (RPS Composition)

	Totals excluding biogenic CO_2		**Totals including biogenic CO_2**	
	Landfill	**Incineration**	**Landfill**	**Incineration**
20 year total	518,443	26,911	701,012	958,411
150 year total	766,384	26,911	1,136,828	958,411

Notes

Totals assume 90,000 tonnes of residual waste is treated annually for 20 years.

Figure 1: Annual Impacts over a 20 Year Period (from 90,000 tonnes per year) – Including Biogenic CO_2 Emissions

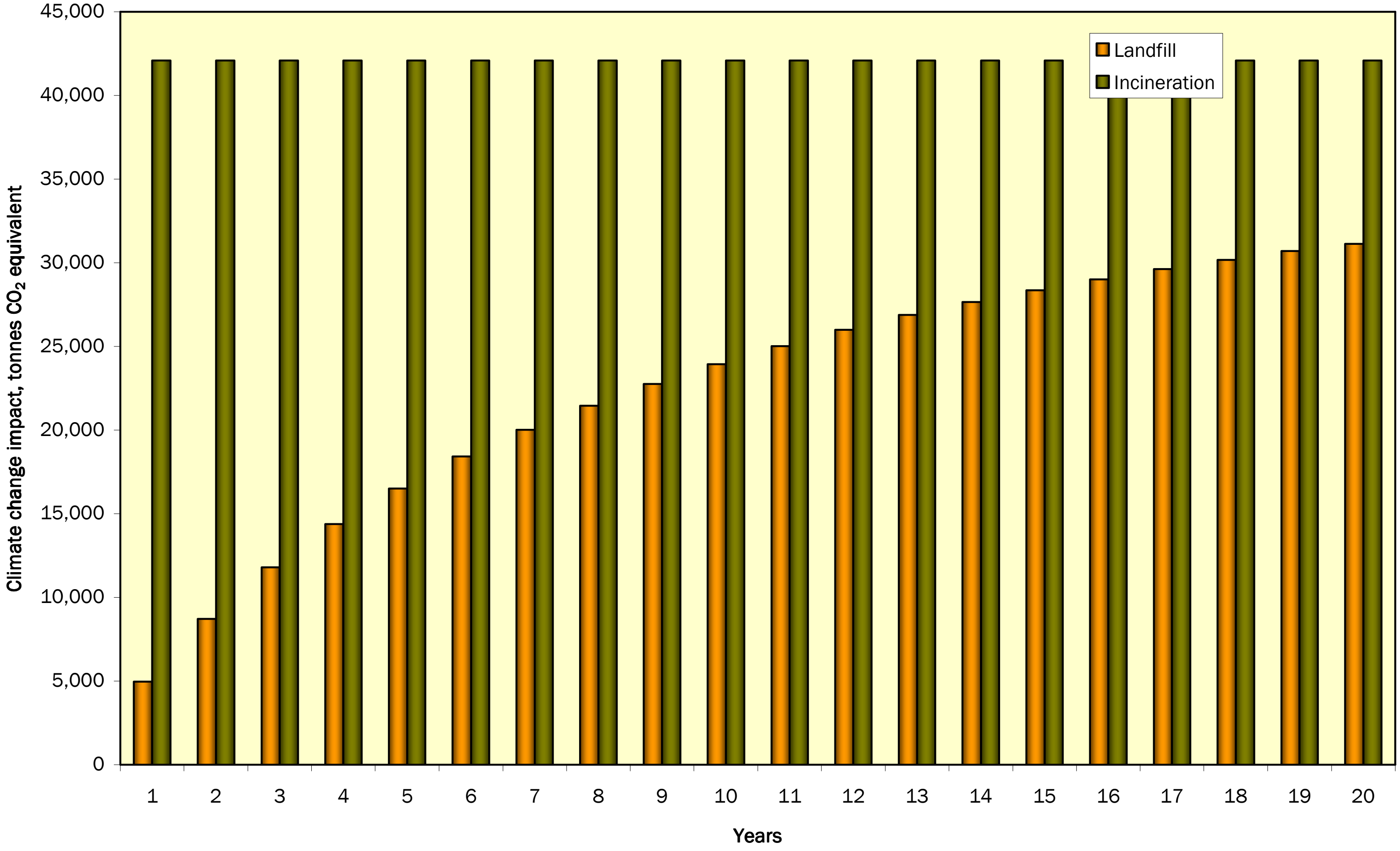

Figure 2: Annual Impacts over a 20 Year Period (from 90,000 tonnes per year) – Excluding Biogenic CO_2 Emissions

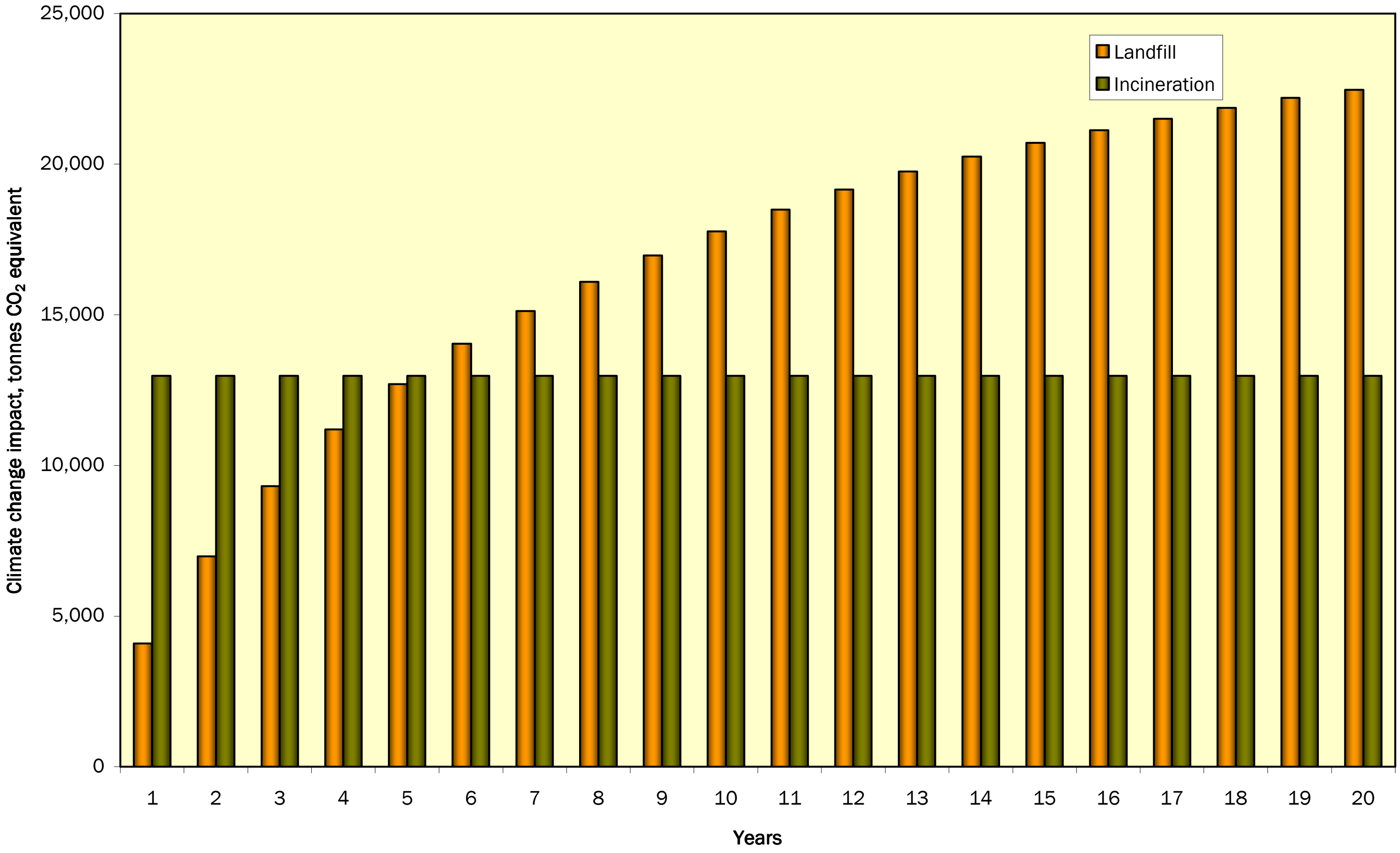

Table 5 provides a breakdown of the total impact associated with treating 90,000 tonnes of waste, using the indicative transport impacts provided by RPS along with the same residual waste composition used in their analysis (with the impact of each tonne landfilled considered over a 150 year period).

Eunomia's waste treatment model Atropos assumes a lower biogenic carbon content than that of the model used by RPS in their analysis, resulting in a lower emissions impact for landfill in the current study when compared to that calculated by RPS, even where biogenic CO_2 emissions are included. RPS's analysis also assumes a lower fossil carbon content for plastic film and dense plastic and this leads to lower impacts associated with incineration in their study when compared with the results from this analysis.

Table 5: Breakdown of Emissions Impacts (from 90,000 tonnes of Residual Waste)

	Emissions, tonnes CO_2 equivalent	
	Landfill	**Incineration**
Process emissions excluding biogenic CO_2	40,969	26,270
Process emissions including biogenic CO_2	59,491	72,845
Emissions offsets	-2,650	-24,924
Transport	6,868	5,363
Totals excluding biogenic CO_2	45,187	6,709
Totals including biogenic CO_2	63,709	53,284

Notes

The Table provides the impacts from landfilling or incinerating 90,000 tonnes of waste with impacts calculated using Eunomia's model (but assuming the same residual waste composition as was the case in the RPS analysis). In the case of landfill, calculations give the impact of each tonne over a 150 year time period.

Emissions offsets include the generation of electricity from both facilities (in the case of landfill this results from the combustion of captured landfill gas) and from the recycling of ferrous metal at the incinerator.

Indicative transport impacts are taken from RPS (2009).

3.3 Landfill Gas Capture Sensitivity

The results in this section consider climate change impacts that result from the two treatment processes where only 20% of the landfill gas is assumed to be captured – this being the default assumption indicated in the 2006 Guidance published by the IPCC.[18] We would consider that landfills in the UK are somewhat better engineered

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[18] IPCC (2006) IPCC Guidelines for National Greenhouse Gas Inventories: Chapter 3 – Solid Waste Disposal

than in the general (global) case, although a recent report by the European Environment Agency uses the IPCC figure for all EU countries, including the UK.[19] It should be noted, however, that the default assumption used in the UK by Defra and the English Environment Agency is 75% gas capture, although this figure is under review pending results from monitoring programmes currently being undertaken by the Agency.

Total impacts are shown in Table 6. These results confirm that where a lower landfill gas capture is assumed, incineration performs better than landfill even where biogenic CO_2 emissions are included.

Table 6: Total Emissions from Landfilling and Incineration (Lower Gas Capture)

	Totals excluding biogenic CO_2		Totals including biogenic CO_2	
	Landfill	Incineration	Landfill	Incineration
20 year total	435,316	259,462	538,311	841,868
150 year total	801,323	259,462	990,156	841,868

Notes

Totals assume 90,000 tonnes of residual waste is treated annually for 20 years.

4.0 Conclusions

Our analysis indicates that where biogenic CO_2 results are included, and the results for landfill are considered over a 150 year period, climate change impacts associated with landfilling Shropshire's residual waste are lower than those associated with incineration.

Results are sensitive to assumptions surrounding composition and landfill gas capture. When results are obtained using the waste composition used in previous modeling undertaken by RPS for Veolia, landfill performs less well than incineration when the biogenic CO_2 emissions are included. This composition is felt however to be less representative of the likely residual waste composition for Shropshire due to the relatively low plastics content. As recycling rates improve, this tends to concentrate the plastic material in the residual stream as such material is less well captured by recycling schemes. The composition used in the central case has a plastics content of 11%; in contrast, the composition used by RPS in their earlier analysis indicated a plastic content of 7%.

When only 20% capture of landfill gas is assumed, incineration performs better than landfill even where biogenic CO_2 emissions are included. We would consider, however, that landfills in the UK are somewhat better engineered than in the general (global) case, such that gas captures in the UK are likely to be higher than this.

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[19] Skovgaard M, Hedal N, Villanueva A, Andersen F and Larsen H (2008) Municipal Waste Management and Greenhouse Gases, ETC/RWM Working Paper 2008/1, January 2008

When the biogenic CO_2 emissions are excluded from the analysis, landfill performs very poorly in comparison to incineration. The need to include biogenic CO_2 has been recognised for a number of years by some of those involved in life-cycle assessments. Although much of the analysis published in this field in recent years excludes these impacts, we believe the inclusion of these emissions provides a more accurate analysis of the climate change impact.

Annex:

Eunomia’s response to Simon Aumonier’s evidence

Ann Ballinger

On biogenic carbon

We did not claim to produce analysis that was consistent with the LCA methodology as it is currently practiced. Our aim was to explore the sensitivities of assumptions made in this type of analysis, and to examine the impact of a different approach upon the results.

The approach recommended by ERM – and taken by the majority of LCA practitioners - is likely to underestimate the climate change impacts of incineration relative to landfill, as is confirmed by their evidence. ERM acknowledge that to be methodologically correct according to both LCA and GHG accounting, there should be a credit applied back to the system to account for the permanent store of carbon through waste management, but indicate there is no agreed methodology for doing this. As such this credit is typically not applied; the resulting analysis thus overestimates emissions from landfill, although it has no impact on the modelling of the performance of an incinerator.

Secondly, ERM confirm in their evidence that the “simplification” (regarding the ignorance of biogenic CO_2 emissions) can only be correctly applied when the biogenic CO_2 is from a renewable source, so that there is no net change in the amount of biomass available. The assumption may therefore be appropriate for a reasonable proportion of food waste. For paper and card, they confirm that we have to assure ourselves that these waste products come from sustainable forestry practices; presumably, the same also applies to wood waste. The simplification might not be unreasonable for many forestry products produced in Northern Europe, but is likely to be less appropriate for those that originate from elsewhere. It is not clear what approach should be taken for garden waste, textiles made from natural fibres or absorbent hygiene products – and the latter two categories accounting for an increasingly significant proportion of the residual waste stream. The impact of the simplification is to underestimate the climate change impacts of both treatment methods. Impacts will, however, be underestimated to a more significant extent for incineration, as a proportion of the biogenic carbon is sequestered when material is landfilled.

As ERM indicate in their report, there is a need to confirm system boundaries when LCA is being undertaken. They present the case for the conventional approach taken by the majority of LCA practitioners. However, it is clear that not all in the LCA community agree with the conventional approach to boundary determination,[1] and the approach has similarly been questioned by others outside this community.[2]

We acknowledge that all analysis of this type is a simplification and that our approach is more likely to lead to an overestimation of the impacts of both treatment methods. However, in line with the authors previously cited, we feel that the more conservative approach is justified, given the importance to society of understanding climate change impacts.

On treating incineration unfairly

ERM suggest that assumptions used in our analysis are “highly selective and biased in one direction”. Their evidence then goes on to discuss our assumptions with regard to bottom ash treatment. We accept that we underestimated the recovery of metals from the incinerator basing our analysis on data from plant currently operating that did not use the services of a recovery specialist. Assuming the latter was the case, this might result in a reduction in the climate change impact of 34 kg CO_2 equivalent per tonne of waste treated (using the Bishop’s Castle composition and ERM’s recovery assumptions).

Interestingly, however, no reference is made in ERM’s evidence to our very conservative approach when modelling the performance of landfill. Our analysis retains the 50% landfill gas capture rate used by RPS, and our report confirms this as such. However, we note that ERM typically assume a capture rate of 75% - as do many others when considering the performance of UK landfills (75% is the capture rate assumed within the WRATE software, for example, and in MelMod, the model used by the UK Government to estimate landfill emissions for the purpose of the IPCC inventory).[3] This assumption has a far more significant impact on the results than the underestimation of metals recovery; assuming biogenic CO_2 emissions are included, the use of a 75% capture rate reduces the impact of landfilling the waste by 134 kg.

On waste composition

ERM imply that the composition used in our analysis is unrealistic, suggesting that the composition used by RPS is inherently more accurate because it was undertaken for the whole of Shropshire rather than for just one district. We accept that in general it

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[1] G. Finnveden, J. Johansson, P. Lind and A. Moberg (2000) *Life Cycle Assessments of Energy from Solid Waste*, FMS: Stockholm; Rabl A, Benoist A, Dron D, Peuportier B, Spadaro J V and Zoughaib A (2007) How to Account for CO_2 Emissions from Biomass in an LCA, *Int J LCA*, 12(5) p 281

[2] Searchinger T D, Hamburg S P, Melillo J, Chameides W, Havlik P, Kammen D M, Likens G E, Lubowski R N, Obersteiner M, Oppenheimer M, Robertson G P, Schlesinger W H and Tilman G D (2009) Fixing a Critical Climate Accounting Error, *Science*, 326, pp527-528

[3] See for example, ERM (2006) Impact of Energy from Waste and Recycling Policy on UK Greenhouse Gas Emissions, Final Report for Defra, January 2006

would be advisable to use a waste composition that is representative of the larger geographical area. We felt, however, that the composition used by RPS was likely to be less representative of current waste management practice in Shropshire, given its low plastics and textiles content.

Our analysis does not use a composition containing 15% plastic – and our report does not actually say this was the case (although it is accepted that this could be implied on an initial reading of our discussion). The waste composition from Bishop's Castle composition contains 11% plastics.

However there is a reasonable body of evidence to suggest a plastics content of 15% in residual waste is not unrealistic. Defra's national composition from 2006/7 is the most comprehensive survey we have of composition analyses, amalgamating information taken from over 800 national composition analyses done in the UK at that time. Combining the national kerbside composition data in the national set (this includes both kerbside recycling and kerbside residual) with the indicative capture rates for dataset suggests that in 2006/7, the proportion of plastics in the residual waste stream was 15%.[4]

At this point the national recycling rate was 25%. Recycling has since increased to just over 40% with new collections being rolled out for mixed plastics and food waste. However, the national dataset confirms that 43% of the plastic stream is film – currently still largely unrecyclable. Of the remaining dense plastics, whilst bottle captures have improved, mixed plastics collections are still perform less well and non-packaging plastics are not recycled. Food waste captures are also still relatively modest as many areas do not have a collection; even where collections do exist, these are often commingled organics collections which do not result in significant food waste capture. Thus recycling rates for these streams are unlikely to have improved up to the levels seen in 2006/7 for the already established collections of other materials. Increased captures of the materials already being captured in 2006/7 are therefore likely to have contributed significantly to the increase in recycling – and will continue to do so as recycling rates improve.

The Table below illustrates the above argument for 25% and 40% recycling, with kerbside arisings data taken from the national composition. Reaching 60% recycling will imply improved captures in both food waste and mixed plastics collections; if both improve, the contribution of plastics to the residual stream is likely to stay at roughly the same level.

Anecdotal evidence for a decrease in recent years of the organic content of residual waste also comes from some plant operators:

- GRL in Lancashire (MBT process with AD) have confirmed operational issues arising from having a much lower amount of organic waste in residual stream than was indicated in the outline business case prior to plant construction;[5]

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[4] Resource Futures (2009) Municipal Waste Composition: A Review of Municipal Waste Component Analyses, Final Report for Defra, March 2009

[5] Personal communication with operational staff at Global Renewables

- Another plant operator's experience suggests a residual waste stream containing in excess of 20% plastics is a regular occurrence.[6]

The second point confirms that there will be local variations – but these could result in a significant increase in plastics as likely as they might imply a significant decrease.

	Kerbside collected waste (tonnes per year)	2006/7 data (25% recycling)		40% recycling	
		Capture for recyclables	Resulting residual composition	Capture for recyclables	Resulting residual composition
Food waste	4,508,285	1%	32%	10%	36%
Garden	2,516,371	75%	5%	85%	3%
Other organics	391,327	3%	3%	5%	3%
Paper	3,635,357	50%	13%	80%	7%
Card	1,013,142	28%	5%	70%	3%
Glass	1,164,881	40%	5%	55%	5%
Metals	617,743	23%	3%	40%	3%
Plastics	2,042,743	7%	14%	18%	15%
Textiles	547,274	6%	4%	10%	4%
Wood	157,092	3%	1%	10%	1%
WEEE	192,535		1%		2%
Hazardous	71,281		1%		1%
Sanitary	662,259		5%		6%
Furniture	3,813		0%		0%
Mattresses	0		0%		0%
Misc	198,750		1%		2%
Misc	289,643		2%		3%
Soil	0		0%		0%
Other wastes	406,668		3%		4%
Fines	287,459		2%		3%

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[6] Personal communication with operational staff at New Earth Solutions (relating to their Canford facility in Dorset)