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UK Without Incineration

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UKWIN's response to Defra's Call for Evidence to inform the UK Government's Review of Waste Policies

UKWIN believes that the current "dump it or burn it" mindset undermines sustainability and is fundamentally hostile both to enhancing the environment and to the Government's other objectives.

4th October 2010

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1. Introduction

1.1. UKWIN welcomes this opportunity to participate in the Government's review of waste policy. UKWIN applauds the Coalition Government's stated aspiration to become the greenest government ever, and we are committed to working positively with the Government to support the realisation of this ambition.

1.2. The United Kingdom Without Incineration Network (UKWIN) was founded in March 2007 to help local groups develop the case against waste incineration and engage positively with the planning system, and in doing so create a UK-wide movement in favour of more sustainable approaches to waste management.

1.3. UKWIN currently has some 75 member groups, all of whom were consulted in the drafting of this submission.

1.4. UKWIN's vision is in harmony with the One Planet Living goal featured in the 2007 Waste Strategy. One Planet Living should go hand in hand with the Government's commitment to a zero waste economy. Most importantly, a zero waste economy, and a trajectory that would move us closer to One Planet Living, must emphasise ongoing reductions in the quantities of all wastes arising.

1.5. UKWIN sees zero waste contributing to reducing energy requirements, reducing CO2 emissions, reducing imports, and reducing damage to our environment. Incineration goes against all of these aims.

1.6. UKWIN notes that Waste Strategy 2007 stated that: "We are living beyond our environmental means. If everyone consumed as many natural resources as we do in England, then WWF (the World Wide Fund for Nature) suggests we would need three planets to support us. Using the planet's resources within the limits of its eco systems is vital to the survival, health and prosperity of future generations"; and that: "The most crucial threat from exceeding environmental limits is that of dangerous climate change".

1.7. UKWIN believes that the current "dump it or burn it" mindset undermines sustainability and is fundamentally hostile both to enhancing the environment and to the Government's other objectives.

1.8. For the purpose of this submission, UKWIN uses the term "incineration" to cover all technologies subject to the Waste Incineration Directive. This includes mass burn incineration (with or without heat capture), advanced thermal treatment, gasification, and pyrolysis.

1.9. UKWIN notes and comments briefly upon, the Government's stated priorities as follows:

1.10. **Tackling the fiscal deficit**

1.10.1. A true zero waste strategy will lead to reduced imports, improved security of supply and cost savings through the more effective use of resources.

1.10.2. Current policies that profit the waste management industry at the expense of householders must be reversed. UKWIN calls for a hasty end to all subsidies for incineration thereby freeing up money to help reduce the fiscal deficit.

1.10.3. UKWIN calls for the introduction of an incineration tax (starting at a minimum of £40 per tonne) to ensure economic benefits reward resource efficiency, reduction, reuse, repair, recycling (precycling, freecycling, upcycling, etc.), composting and AD, and to add to the financial resources available to tackle the fiscal deficit.

1.11. **Environmental protection**

1.11.1. Decision-makers should adopt a precautionary approach to planning applications in general and to applications for waste incinerators in particular.

1.11.2. Ensure sites for waste facilities are appropriate, i.e. not greenfield, nor close to vulnerable populations and other sensitive receptors.

1.11.3. Give priority consideration, in line with the 2007 Persistant Organic Pollutants (POPs) regulations and the Stockholm Convention, to alternatives to incineration that do not give rise to persistent organic pollutants (POPs). Such consideration should include waste minimisation, enhanced recycling provision, and changes to collection methodologies, e.g. separate collection of food waste.

1.11.4. Keep waste facilities small, modular and local, and ensure waste contracts are flexible, i.e. responsive to changes in waste composition and new technological developments, in order to derive the environmental benefits of future innovation.

1.11.5. This is echoed in the testimony of the Environment Agency's Head of Waste, delivered to the Environment, Food And Rural Affairs Committee: Waste Strategy For England

2007[1]: "...Defra's advice on the Waste Strategy is very clear, that local authorities need to avoid being locked into long term contracts or plant that is too big. They need to be responsive to future, technological changes."

1.11.6. Subject existing waste incinerators to greater scrutiny, including ending the self-regulation of incinerator bottom ash toxicity classification, increase the frequency of emissions monitoring and extend the number of emissions that are monitored – making greater use of continuous emissions monitoring systems, and impose tighter restrictions on emissions than is required by the Waste Incineration Directive (WID), and take more forceful action in response to exceedances.

1.11.7. UKWIN also calls for more stringent regulation of hazardous incinerator ash that is sent to landfill, to avoid further occurrences such as that at Bishop's Cleeve[2].

1.11.8. Adopt strategies that recognise:

i. The benefits from recovering energy efficiently and cleanly from separately collected food waste using AD.
ii. That burning recyclables through incineration is damaging to the environment.
iii. The shorter term and strategic benefits of turning green wastes into compost so as to displace artificial fertiliser and improve soil quality.

1.12. **Localism**

1.12.1. Ensure local authorities are obliged to engage their residents at every stage of waste planning and implementation, including procurement.

1.12.2. Give communities the automatic right to appeal all incineration-related planning decisions, and make explicit that local opposition to waste incinerator proposals should be treated as a material planning consideration, alongside the public perception of health dangers associated with waste incineration.

1.12.3. Ensure that the financial rewards of segregating discarded materials are returned to those who segregate, allowing greater rewards for greater segregation.

[1] From Transcript of Oral Evidence, EV14, 15th October 2008, published as HC 1100-i. http://www.publications.parliament.uk/pa/cm200708/cmselect/cmenvfru/uc1100-i/uc110002.htm

[2] For evidence of APC residue having been released into the atmosphere see: http://www.thisisgloucestershire.co.uk/news/Hazardous-waste-escaping-Bishop-s-Cleeve-site/article-2321415-detail/article.html

1.12.4. Make the cost of waste services more transparent, e.g. by putting all public waste contracts and waste invoices on the Internet without redaction, so that householders can assess whether or not they are receiving value for money.

1.13. **Big society**

1.13.1. Promote and support the emergence of local waste collecting, sorting and reselling cooperatives.

1.13.2. Provide tax breaks for charity shops, community groups and social enterprises working to reduce, repair, reuse, recycle, compost, etc.

1.13.3. Outlaw contracts that prevent profitable elements of the waste stream being used by charities, e.g. waste contracts that oblige local authorities to deliver all waste collected to specified contractors and their sub-contractors.

1.14. **Addressing climate change**

1.14.1. Recycling saves energy, prevents greenhouse gas (GHG) emissions, and preserves natural resources. Energy recovery by incineration, by virtue of GHG emissions (that KWh for KWh far exceeds those of a gas fired powered station) is counter-productive and polluting.

1.14.2. It should be noted that plastics do not release GHGs when landfilled, but they do when incinerated. In addition, when landfilled plastics can be mined at a future date, when economics allow, providing future generations with the benefit of those resources.

1.14.3. When comparing technologies in relation to climate change impacts, short-cycle (biogenic) carbon should be included in the assessment, and not discounted as if incineration of biogenic material is somehow carbon neutral.

1.14.4. Whilst it is true that electricity from incineration offsets carbon emissions from substituted generation, the future electricity mix has to be modelled. Current policy requires a progressive reduction in the carbon intensity of the future fuel mix, which substantially reduces the benefits of electricity produced via incineration as future electricity comes with much lower carbon emissions.

2. Executive Summary

2.1. The Government's approach to zero waste must focus on the principles of the waste hierarchy and on the One Planet Living goal.

2.2. Current attitudes and waste management methodology are inconsistent with the achievement of zero waste. Much existing methodology, particularly for domestic waste, focuses on disposal (via incineration or landfill) rather than reuse and recycling, with scant regard given to minimisation.

2.3. The existing concept of the inevitability of waste has to be replaced by one that views surplus material as a potentially valuable resource that should not be incinerated. The circulation of non-recyclables must be progressively eliminated and the concepts of 'mixed' and 'residual' waste have to become those of the past.

2.4. The 'zero waste' concept does not imply that people and businesses will cease to have material for which they have no further use. What it does imply, by definition - for manufactured products - is a commitment to total recycling and reuse, and - for food and garden waste - a state of total recycling that may include anaerobic digestion.

2.5. There must be a proactive framework that recognises the imperative to treat materials as resources at all points in a closed-cycle and that supports maximum reuse and recycling, including the creation and operation of entrepreneurially-oriented reuse and recycling enterprises, whilst phasing out non-reusable and non-recyclable materials and the use of environmentally-unfriendly disposal solutions such as incineration.

2.6. Waste volumes are already falling (see section 3 of this evidence) and, given the potential for recycling, the Government should take urgent steps to prevent further provision of waste incineration plants, as these are inconsistent with maximised recycling.

2.7. **UKWIN strongly believes that:**

2.7.1. Whilst we accept that local authorities should govern their own patches, the current household waste collection and disposal arrangements are inconsistent with the need to incentivise recycling and engage local businesses, communities and individuals as stakeholders.

2.7.2. The Government should install a new legislative, fiscal, regulatory, incentive and data collection framework which, for manufacture material supports a closed product loop starting and finishing with manufacture and in which extended supplier responsibilities are complemented by consumer incentives and a buoyant, entrepreneurially-oriented, resource recovery market, together with effective resource tracking systems.

2.7.3. The Government should look carefully at the nature of the players needed within the resource recovery market and, by implication, the responsibilities that local authorities should carry and the roles that, in conjunction with existing C&I and C&D recycling businesses, entrepreneurially-oriented community cooperatives could play.

2.7.4. Incineration diverts resources from recycling and diverts biogenic resources from composting and effective energy recovery via AD. The installation of incinerators, which are inherently energy inefficient, produce toxic emissions and massive quantities of $CO2_e$ and do not save on GHG emissions, should cease forthwith, and pending the achievement of zero waste, inert non-recyclables should be put to landfill.

2.7.5. Incineration plants devalue the local environment and its communities and do not, for the most part, produce 'renewable electricity'. The mixed waste upon which they rely will normally contain a substantial proportion of plastic material. In respect of the biogenic content, there is unlikely to be any assurance that any, or all, of the material will be renewed.

2.7.6. The Government should at least, pending the outcome of the review, impose a moratorium on incinerator planning applications and insist on alternative solutions. Incineration should not qualify for Renewable Obligation Certificates (ROCs) or Packaging Recovery Notes (PRNs).

2.7.7. In all cases where energy recovery solutions are proposed, all technical options should be subjected to comprehensive and fair Life Cycle Analysis comparisons.

2.7.8. The separation of waste types at source (domestic and commercial) is essential if recycling is to be maximised.

2.7.9. Green (garden) waste should be composted. Compost replaces chemical fertilisers, thereby saving energy, and providing benefits for soil quality.

2.7.10. AD is the best solution for the recovery of renewable energy from food waste, particularly if the biogas is fed into the National Grid. Energy recovery via AD can play a major role in improving security of supply and reducing reliance on fossil fuel imports, and thereby can further reduce our carbon footprint.

2.7.11. The review should not overlook the potential opportunities for carbon sequestration, including plastics sent to landfill.

2.7.12. The use of manufactured materials for energy recovery by incineration is inefficient, unnecessary and hugely damaging to communities and the environment. Recycling saves energy and GHGs.

3. General

3.1. England has passed the point of peak municipal solid waste (MSW) production.

3.2. MSW per household peaked in 2002/03, and fell well before England entered recession.

3.3. The amount of Commercial and Industrial (C&I) waste still needing diversion from disposal has been considerably over-estimated in national and regional plans.

3.4. Official data shows MSW has been falling per head since 2002/03 and that there has been an overall tonnage fall since 2004/05.

3.5. Defra statistics show how much total waste is disposed of in landfills or burned in incinerators. It is difficult to quantify how much non-municipal waste is being produced. Based on disposal and treatment statistics it is however clear that there is now far less C&I waste than had been expected.

3.6. **Trends in Total Municipal Solid Waste**

3.6.1. A step-change in waste arising took place when councils provided free garden waste collections and switched to wheelie bins. These changes increased the capacity for homeowners to dispose of waste instead of composting it at home.

3.6.2. While the grass has always grown, it is increasingly included in the figures for MSW instead of being mulched, burned or composted at home.

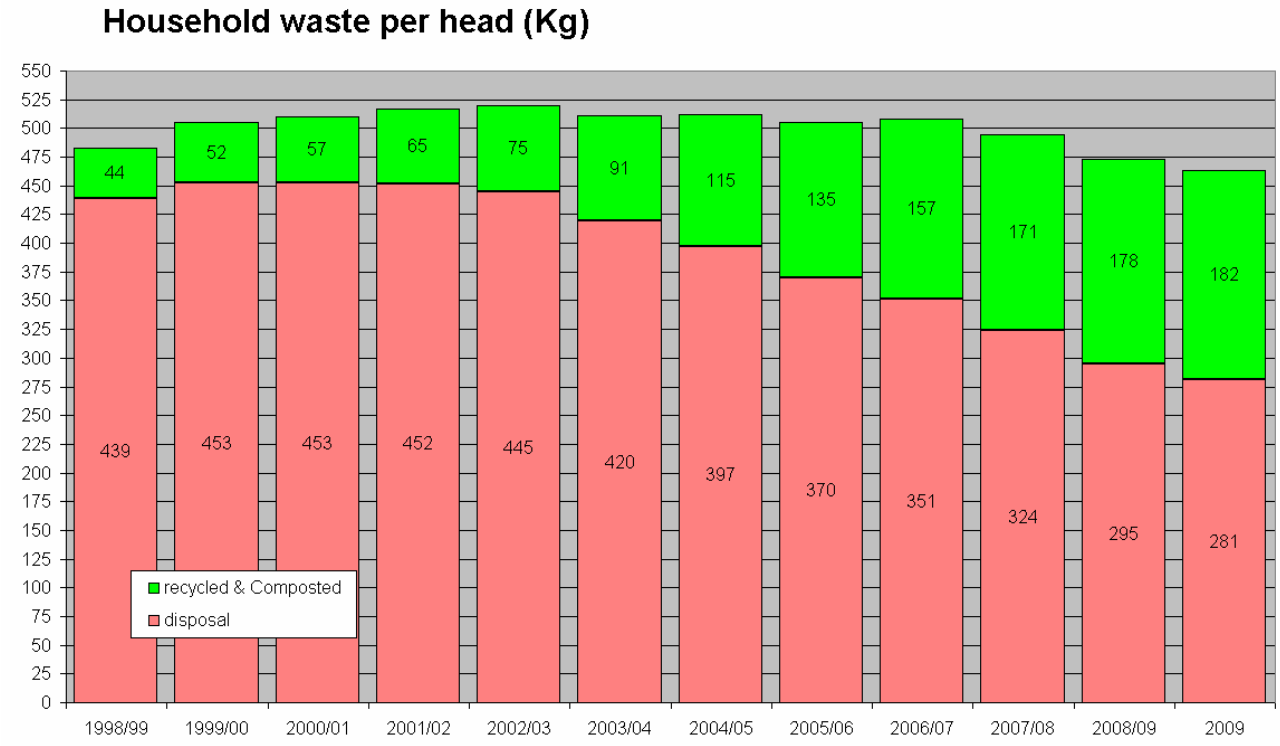
3.6.3. The apparent growth in domestic waste ran out of steam in 2004/05. The average person in England has been producing around half a tonne of waste per year for the last decade.

3.6.4. The English per-head average in 2002/03 was 520Kg (see Table 1 and Figure 1, overleaf). There is a variation from year to year due to the increase in garden waste in some damp summers and reductions in garden waste in drought years (such as the summer of 2005).

Table 1 - Annual household waste per head (in kg per head per year)
(Source: Defra 2008/09 waste statistics)

	Waste not recycled/ composted/ reused	Waste recycled/ composted/ reused	**Total household waste**
1997/98	440	39	**480**
1998/99	439	44	**482**
1999/00	453	52	**505**
2000/01	453	57	**510**
2001/02	452	65	**516**
2002/03	445	75	**520**
2003/04	420	91	**510**
2004/05	397	115	**512**
2005/06	370	135	**505**
2006/07	351	157	**508**
2007/08	324	171	**495**
2008/09	295	178	**473**

Figure 1 – Household waste per head per year (using Defra data)



3.6.5. Offsetting the fall in waste per head is a steady rise in population, especially in the South East of England.

3.6.6. The effect of this was to delay the year of “peak waste” to 2004/5.

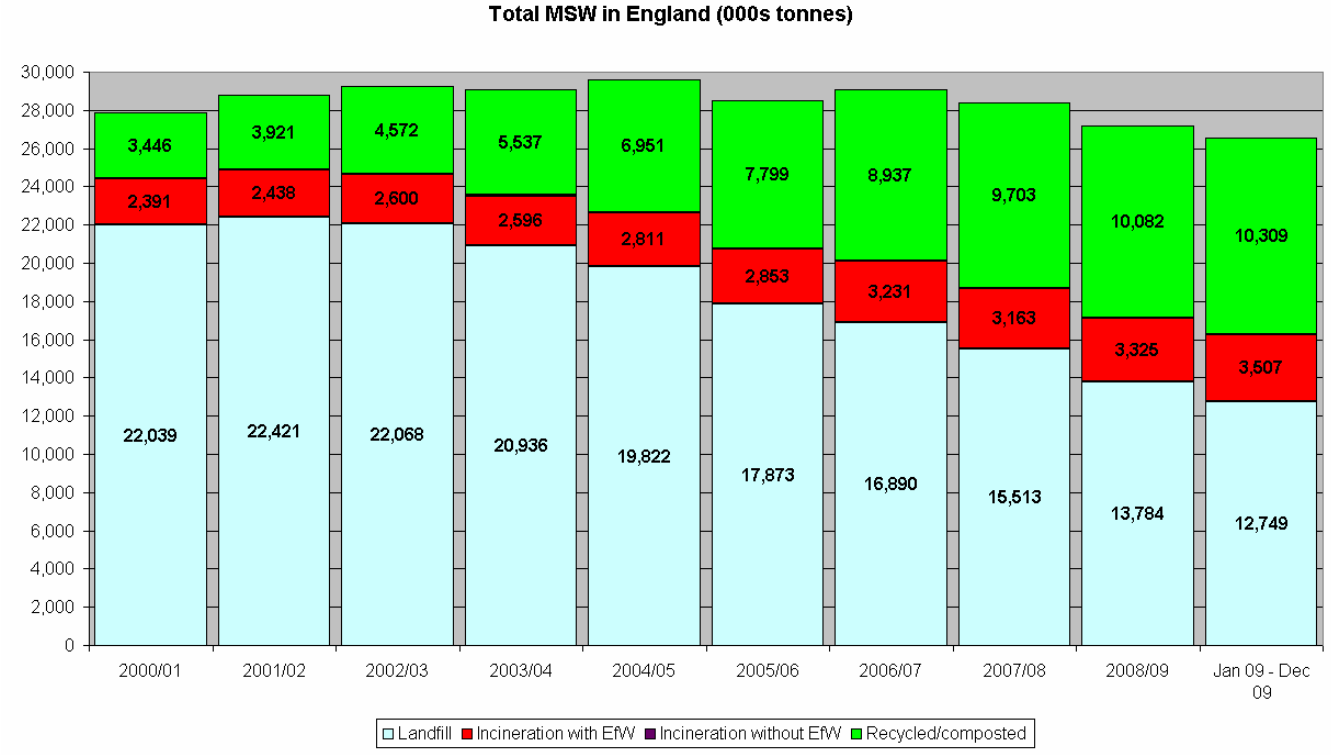
3.6.7. Defra's municipal waste statistics show this peak was 29.62 million tonnes. The latest official data from Defra showed total MSW collected had dropped to 26.758 million tonnes for the 2009 calendar year. Statements that waste is continuing to increase are no longer justifiable.

3.6.8. Some local authorities seem to be out of step with the latest waste trends, for example Nottinghamshire County Council still claim that "waste has the potential to double over the next 20 years" (i.e. increase from 450,000 tonnes in 2000 to 900,000 tonnes in 2020, despite waste arisings having fallen to around 400,000 tonnes), and the Council is attempting to proceed as if this were a realistic prospect.

Table 2 – Total MSW disposal
(source: DEFRA 2008/09 annual and 2009/10 Q3 statistics)

Method	England									
	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009
Landfill	22,039	22,421	22,068	20,936	19,822	17,873	16,890	15,513	13,784	12,749
(percentage)	*79%*	*78%*	*75%*	*72%*	*67%*	*62%*	*58%*	*54%*	*50%*	*48%*
Incineration with EfW	2,391	2,438	2,600	2,596	2,811	2,853	3,231	3,163	3,325	3,507
(percentage)	*9%*	*8%*	*9%*	*9%*	*9%*	*10%*	*11%*	*11%*	*12%*	*13%*
Incineration without EfW	20	9	7	8	7	6	6	5	6	6
(percentage)	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Recycled/composted	3,446	3,921	4,572	5,537	6,951	7,799	8,937	9,703	10,082	10,309
(percentage)	*12%*	*14%*	*16%*	*19%*	*23%*	*27%*	*31%*	*34%*	*37%*	*38%*
Other	162	116	146	38	27	195	122	121	198	240
(percentage)	*1%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*0%*	*1%*	*1%*
Total	**28,057**	**28,905**	**29,394**	**29,114**	**29,619**	**28,726**	**29,187**	**28,507**	**27,395**	**26,810**

Figure 2 – Total MSW disposal
(source DEFRA 2008/09 annual and 2009/10 Q3 statistics)



3.6.9. The last year on Table 2 (above) is for the calendar year 2009 as Defra have yet to release the full 2009/10 data. The data already in the public domain indicates that the outturn for 2009/10 will show even less landfilling and an even greater reduction in total waste.

3.6.10. Incineration capacity has changed little over the past few years, with just one significant addition of capacity at Allington in Kent.

3.6.11. The Allington plant, with a capacity of 500,000 tonnes per year, has had significant technical problems that meant it was not fully operational in either 2007 or 2008. This has resulted in an extended commissioning period with long maintenance outages and thus its capacity has come on-line slowly over a period of several years.

3.6.12. Over the last 9 years there has been approximately 200% more recycling and composting but less than a 50% increase in incineration.

3.6.13. The drop in landfilling to 12.7 million tonnes per year from around 22 million tonnes has greatly extended the life of existing landfills.

3.6.14. So far this century the amount recycled/composted has increased each and every year.

3.6.15. Most of the sharp fall in waste to landfill has been produced by an increase in the tonnage of recycling and composting.

3.6.16. The municipal waste statistics do not show the ash produced by incineration as this is classified as commercial & industrial (C&I) waste. As a result, incineration of MSW increases total waste.

3.7. Quantifying residual C&I waste

3.7.1. It has long been assumed that there is around twice as much C&I waste as MSW. For many parts of England this assumption does not seem valid. In 2009 the tonnage of non-inert waste going to landfill in the UK was 27 million tonnes[3]. Of this, around 15 million tonnes was MSW (of which 12 million tonnes is non-inert waste from England). This implies there was around 12 million tonnes of non-inert C&I waste being landfilled in 2009 in the whole of the UK.

[3] Source: HMRC Landfill Tax Bulletin – UK trade data website: https://www.uktradeinfo.com/

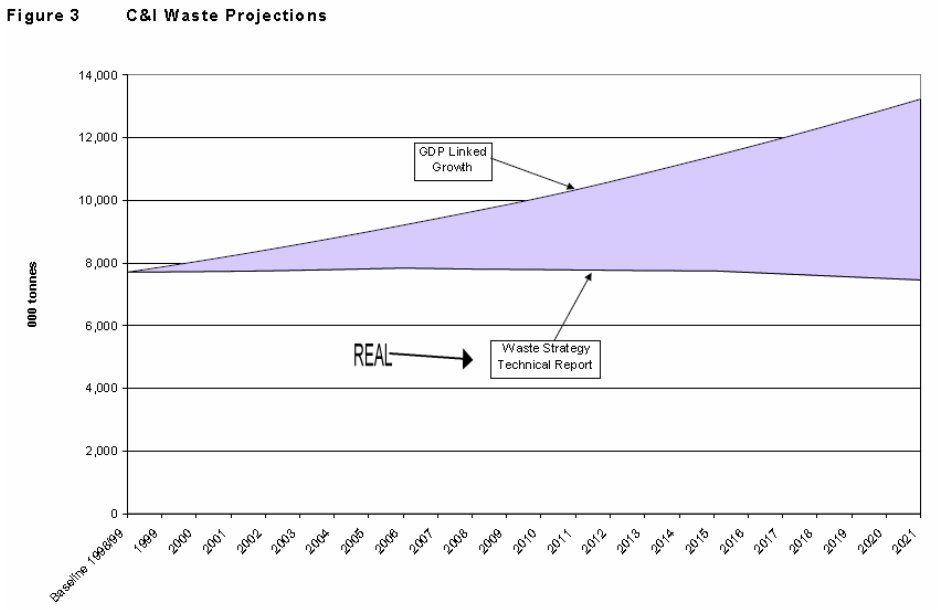
3.7.2. These 12 million tonnes of UK non-inert C&I discards are being targeted by the incineration industry, by promoters of anaerobic digestion, by operators of material recycling facilities and by waste minimisation and reuse initiatives.

3.7.3. The majority of the rest of the residual C&I waste stream will be material such as ash In areas with major coal power stations such as Nottinghamshire and South Wales the ash can be the largest component of the residual waste stream. Some of this ash is used in building materials and construction. The use of incinerator ash merely reduces the amount of other ash that can be reused.

3.7.4. The C&I projections used by local and regional government are deeply flawed. This can be seen by looking at the East Midlands Regional Assembly (EMRA) treatment capacity study. The study envisages total C&I waste rising from 7.8 million tonnes in 2003 to between 7.8 and 10.1 million tonnes in 2010. Unless the region has a remarkable C&I recycling rate these figures must massively overestimate the amount of C&I produced. In 2009 just 2.7 million tonnes of municipal, commercial and industrial waste was landfilled in the region. 1 million tonnes was municipal waste and 0.7 million tonnes was inert power station ash, leaving just 1 million tonnes as residual C&I and waste imported from the South East.

3.7.5. The figure below is an excerpt from the EMRA report[4] showing projected total East Midlands C&I arisings. The real tonnage of C&I will be around 4 - 5 million tonnes in 2010.

Figure 3 C&I Waste Projections



[4] Study to Determine the Current and Future Waste Treatment Capacity of the East Midlands Region, Phase Two (Enviros Consulting, July 2006) http://www.nottinghamshire.gov.uk/large-static/erf/cd41a_waste_treatment_phase2_jul06.pdf

3.8. The Executive Summary of the North West of England Commercial and Industrial Waste Survey 2009 (dated March 2010)[5], compiled for the Environment Agency by Urban Mines, draws comparisons with the 2006 survey and states that: "The 2006 survey recorded total waste arisings for the region of 7.53 million tonnes, rising to 8.12 million tonnes when estimates are included for companies employing 4 people or less". Comparing the results of the two surveys, the report states:

3.8.1. Total waste for the 2008/09 survey is 6.0% down on the 2006 survey.

3.8.2. The biggest reduction is seen in the industrial sectors where total waste is 14.25% down over the period whereas the commercial sector figure is 2.5% greater than 2006, with the largest increase in retail and wholesale.

3.8.3. The landfill figure is 62% of 2006 at 1.43 million tonnes. Figures for "don't know" and "transfer station" are significantly down too. All these factors may have contributed to recycling being up to 4.2 million tonnes (+60%) mostly in service sectors of retail and wholesale and public services.

3.8.4. In terms of waste types, animal and vegetable and non-metallic wastes are up on the previous survey (22% and 16% respectively) where as mixed wastes is around the same level as 2006. Big reductions are in industrially associated wastes, chemical, sludges, metallic wastes.

3.8.5. 1.43 million tonnes [were] landfilled (20.2%) with 4.23 million tonnes recycled (59.8%). Of landfilled waste 0.2 million recyclable, 1.12 million potentially recyclable (i.e. after further separation) [indicating that 92.3% of the material that was landfilled could have been recycled].

3.9. **What should the nation's ambition for waste management be?** (part of Questions General 2.3)

3.10. The UK should strive to achieve a sustainable zero waste economy, consistent with One Planet Living, that does not rely upon increasing incineration capacity.

3.11. UKWIN urges the Government to adopt the Zero Waste Alliance International (ZWAI) definition of zero waste (dated 29th November 2004), as follows:

"Zero Waste is a goal that is ethical, economical, efficient, and visionary, to guide people in changing their lifestyles and practices to emulate sustainable natural cycles, where all

[5] Available at http://publications.environment-agency.gov.uk/epages/eapublications.storefront [Product code: GENW0410BSJM-E-E]

discarded materials are designed to become resources for others to use.

Zero Waste means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them.

Implementing Zero Waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health."

3.12. UKWIN believes that building new waste incinerators is antithetical to working towards a zero waste economy, and should therefore cease. Please see A Bridge Half Built: *Zero Waste Declaration* included as Appendix A of this submission.

3.13. UKWIN notes that the concept of “waste” should, over time, become an alien and out-dated concept. Materials that are not required by their owner should be viewed as resources with value to another party, and must therefore be treated as such. There can be no place for manufactured materials that cannot be reused or recycled in a zero waste economy.

3.14. **What do we need to do to achieve a ‘zero waste economy’?** (part of Questions General 2.3)

3.15. We need to achieve profound and rewarding changes in mindset, legislation, regulation, design, management, consumption, purchase and other aspects of what is thought of as “waste”.

3.16. We urgently need to minimise the quantity and toxicity of waste arising.

3.17. We need to maximise reuse, recycling, composting and anaerobic digestion (AD).

3.18. We need to design out materials that cannot be reused, recycled, composted or anaerobically digested.

3.19. We need to treat AD as a form of composting within the context of the waste hierarchy.

3.20. We need to prevent over-provision of incineration capacity at both regional and national levels for social, economic and environmental reasons. We do not need any new incineration capacity to achieve a zero waste economy. UKWIN believes that building new incinerators would be counter-productive.

3.21. We need to see an end to Waste PFI contracts that incentivise incineration over recycling (see the Shropshire Case Study at

Paragraphs 7.19 – 7.23 below), and recycling over reuse and reduction.

3.22. UKWIN also notes that the ZWAI provides measures of success. These principles are outlined in the ZWAI's ten *Zero Waste Business Principles*, and are briefly summarised below:

3.23. The ZWAI state that:
"Businesses and communities that achieve over 90% diversion of waste from landfills and incinerators are considered to be successful in achieving Zero Waste, or darn close."

3.24. *ZWAI Principle 1: Commitment to the triple bottom line*

3.24.1. Ensure that social, environmental and economic performance standards are met together.

3.24.2. Maintain clear accounting and reporting systems and operate with the highest ethical standards for investors and customers.

3.24.3. Produce annual environmental sustainability reports that document how these policies are implemented.

3.24.4. Keep employees, investors, customers and the community informed about all environmental impacts of production, products and services.

3.25. *ZWAI Principle 2: Use Precautionary Principle*

3.25.1. Apply the precautionary principle before introducing new products and processes, to avoid products and practices that are wasteful or toxic.

3.26. *ZWAI Principle 3: Zero Waste to landfill or incineration*

3.26.1. Divert more than 90% of all solid wastes from landfill and incineration, with no more than 10% of discards to be landfilled, and with no mixed wastes to be incinerated.

3.27. *ZWAI Principle 4: Responsibility: Take back products and packaging*

3.27.1. Manufacturers (and their suppliers) and distributors (wholesale and retail) must take financial and/or physical responsibility for all of the products and packaging they produce and/or market.

3.27.2. Support and work with existing reuse, recycling and composting operators to productively use products and packaging, or arrange for new systems to bring those back to

the manufacturing facility of origin.

3.27.3. Include the reuse, recycling or composting of products as a design criteria for all new products.

3.28. *ZWAI Principle 5: Buy reused, recycled and composted products*

3.28.1. Use recycled content and compost products in all aspects of operations, including production facilities, offices and in the construction of new facilities.

3.28.2. Buy reused products where they are available, and make excess inventories of equipment and products available for reuse by others.

3.28.3. Label all products and packaging with the amount of post-consumer recycled content.

3.29. *ZWAI Principle 6: Prevent pollution and reduce waste*

3.29.1. Redesign all supply, production and distribution systems to reduce the use of natural resources and eliminate waste.

3.29.2. Undertake continual assessment of systems, and ongoing revision of all procedures, policies and payment policies to prevent pollution and the waste of materials.

3.29.3. To the extent that products contain materials with known or suspected adverse human health impacts, businesses should be required to notify consumers of their content and how to safely manage the products at the end of their useful life.

3.30. *ZWAI Principle 7: Highest and best use of materials*

3.30.1. Continuously evaluate markets and direct discarded products and packaging to recover the highest value of their embodied energy (without recourse to incineration) and materials according to the following hierarchy:

i. reuse of the product for its original purpose;
ii. reuse of the product for an alternate purpose;
iii. reuse of its parts;
iv. reuse of the materials;
v. recycling of inorganic materials in closed loop systems;
vi. recycling of inorganic materials in single-use applications;
vii. composting of organic materials to sustain soils and avoid use of chemical fertilizers;
viii. composting or mulching of organic materials to reduce erosion and litter and retain moisture.

3.31. Note: UKWIN considers AD to be a form of composting, and we would place AD with composting at v within the hierarchy outlined above.

3.32. *ZWAI Principle 8: Use economic incentives for customers, workers and suppliers*

3.32.1. Encourage consumers, employees and suppliers to eliminate waste and maximize the reuse, recycling and composting of discarded materials through economic incentives and holistic systems analysis.

3.32.2. Lease products to consumers and provide bonuses or other rewards to employees, suppliers and other stakeholders who eliminate waste.

3.32.3. Use financial incentives to encourage suppliers to adhere to Zero Waste Principles.

3.32.4. Evaluate discard material to determine how to develop other productive business opportunities from these assets.

3.33. *ZWAI Principle 9: Products or services sold are not wasteful or toxic*

3.33.1. Evaluate products and services regularly to determine if they are wasteful or toxic and develop alternatives to eliminate those products which are found to be wasteful or toxic.

3.33.2. Assess the benefits from offering machines (e.g. white goods, small plant etc) as a service rather than via outright purchase.

3.33.3. Design products to be easily disassembled to encourage reuse and repair. Design products to be durable.

3.34. *ZWAI Principle 10: Use non-toxic production, reuse and recycling processes*

3.34.1. Eliminate the use of hazardous materials in production, reuse and recycling processes, particularly persistent bio-accumulative toxics.

3.34.2. Eliminate the environmental, health and safety risks to employees and the communities in which businesses operate.

3.34.3. Manage the export of any materials to countries with lower environmental standards according to highest current global environmental standards.

3.35. **How could the contribution waste management in England makes to the economy and our environmental and energy goals be maximised?** (part of Questions General 2.3)

3.36. By following the waste hierarchy on a per-stream basis[6] and ensuring value for money in spending on waste management.

3.37. This would include a greater emphasis on AD and the promotion of more Somerset-style "invest to save" schemes[7] in two-tier authority areas to ensure waste is collected in ways that enable sustainable treatment.

3.38. This would also include separating discarded materials into a far greater number of categories, and increasing the range of materials that are recycled or reused.

3.39. The result would be an increase in higher-quality recyclates that would yield greater financial returns.

3.40. Money should not be wasted on incineration as this technology, within the context of the Government's objectives, represents poor value for money. UKWIN provides further evidence regarding the economic case against waste incineration in Section 7, below.

3.41. Subsidies for incineration should be removed, e.g. incinerator bottom ash (IBA) should be subject to a higher rate of landfill tax. Additionally, a disposal tax that covers both landfill and incineration should be introduced (or at least a £40 per tonne incineration tax).

3.42. Ensure Government-sponsored procurement favours AD and avoids incineration; and ensure that all integrated waste management contracts include tough recycling and waste reduction targets, and are based on robust waste data that avoids over-provision.

3.43. UKWIN also notes that waste management targeted to achieve zero waste to landfill and incineration would reduce materials costs, energy costs and imports.

3.44. To maximise the potential economic contribution of the waste management industry, and to capitalise on the potential benefits of resource efficiency to businesses and households, Government has to provide the appropriate legislative and regulatory framework and incentives.

3.45. UKWIN calls for the establishment of an entrepreneurial framework that includes legislative (e.g. laws requiring Extended

[6] Acknowledging that plastics which are not recycled are better stored in the ground (landfilled) than incinerated.
[7] See http://www.foe.co.uk/resource/event_presentations/somerset.pdf

Producer Responsibility), fiscal, incentivising and regulatory elements. Such a framework would set out the structure within which the roles and expectations of National and Local Government, producers, distributors, consumers, “collection cooperatives”, etc. are defined.

3.46. Such a framework should:

3.46.1. Mandate the principle of Extended Producer Responsibility;

3.46.2. Encourage the recycling and reuse markets in order to minimise and progressively eradicate residual waste;

3.46.3. Discourage and eventually eliminate the wasteful disposal of recyclables to landfill or incineration;

3.46.4. Outlaw inefficient and polluting energy recovery technologies;

3.46.5. Include provision for data capture, including the production of comprehensive baseline data to enable fact-based decision-making;

3.46.6. Recognise current waste volume trends where trends data is available;

3.46.7. Ensure that Life Cycle Analysis (LCA) based comparisons are fully comprehensive and accurately reflect all carbon implications in material life cycles (including biogenic carbon, and the progressive reduction in the carbon intensity of the future fuel mix);

3.46.8. Introduce an entrepreneurial infrastructure (including social enterprises, etc.) that caters for the collection and sale of quality-assured recyclables;

3.46.9. Provide for local community cooperatives and other forms of social enterprise (including community interest companies) wishing to undertake a reusables / recyclables collection service for domestic and commercial consumers for reuse or resale.

3.47. With regard to maximising the contribution to the environment, waste management mindsets and practices that are designed to achieve zero waste can be expected to reduce GHG and toxic emissions, and also to replace chemical fertilisers with compost.

3.48. Energy recovery from salvageable materials must be efficient. AD is a very efficient technology for recovering energy from biowaste, particularly food. Composting saves chemical fertilisers,

improves soil quality and sequesters carbon.

3.49. Salvageable manufactured materials should not be used for energy recovery when, in GHG terms, the materials are best used to source new manufacture, thereby saving energy consumption and emissions.

3.50. We also note the recently-released Friends of the Earth report entitled “More jobs, less waste” (2010) that highlights the benefits to the green economy of increased recycling.

3.51. With regard to maximising the contribution towards the generation and conservation of energy, UKWIN notes that energy efficiency and GHG savings go hand in hand, and that a zero waste strategy would achieve energy savings by reducing energy consumption through recycling, and would replace fossil fuels by generating ‘green’ energy through AD.

3.52. UKWIN strongly disagrees with the classification of waste incineration as a form of low carbon energy generation, for the reasons set out above, and because inert waste should never be seen as a renewable or “green” source of energy, and bio-degradable waste should not be seen as feedstock for incinerators.

3.53. **How can Government make the best use of the skills and knowledge of the private sector, civil society and local communities in delivering a zero waste economy?** (part of Questions General 2.3)

3.54. Working with local communities leads to both better decision making and a greater sense of ownership, helping to avoid lengthy and costly conflicts between communities, local authorities and waste companies regarding proposed waste facilities.

3.55. Conversely, civil society in general and local communities in particular are alienated when incinerators are imposed against their will. Some have expressed experiencing their own local authorities acting as agents for the waste companies intent on forcing through decisions to build waste incinerators without due regard for the views of local residents in the vicinity of the proposed development.

3.56. It must be remembered that citizens are expected to fund waste contracts (directly through Council Taxes and indirectly through national taxes). Householders are also expected to play a crucial role in the delivery of these contracts, e.g. by segregating their discarded materials.

3.57. Increasing numbers of people are learning to segregate their waste, and that means that more of us are coming to see ourselves as stakeholders in the waste sector. In certain respects the public

can be described as unpaid volunteers propping up an industry that profits from our unpaid daily efforts.

3.58. The growing desire of communities to have a greater say in waste management issues may also be associated with the financial implications of the decisions being made on our behalves, and the growing awareness of the “financial investments” that the public makes in order to maintain the current waste system.

3.59. We are not paid for our efforts; as 'volunteers' we are the ones who pay. And members report feeling that we are being called upon to pay and pay, again and again: we pay the shops for wasteful products to be made and transported, we also pay for unnecessary packaging on these products, we pay the WCA for waste to be collected, we pay the waste company for it to be sorted, we pay for it to be transported some more, we pay for it to be burnt in wasteful and unwanted incinerators, we pay for the incinerator’s pollution to be managed, we pay for the toxic ash to be sent to hazardous landfill sites, we all pay for the rising Health Service costs of treating people who have been poisoned by dioxins and other harmful by-products of waste incineration, we pay for the damage done by incineration in relation to climate change, then pay yet again to buy back energy generated from burning our waste, and to top it all off, our money, taxpayers’ money, is going to these same waste companies to help them pay their lawyers and consultants to wage campaigns against us.

3.60. As these waste deals are entered into on our behalf it makes sense that we too should have a role in formulating and reviewing these contracts both in the name of democratic accountability and to ensure that they deliver best value for money.

3.61. Government should require community engagement at all stages of the process, especially before, during and after waste contracts are procured. Whilst Defra guidelines state that: “Proposals should demonstrate that other relevant authorities, the public, and interested parties have been consulted and that there is a broad consensus supporting a recognised long term waste management strategy which is reflected in the proposed solution” our members report numerous instances where projects have gone ahead regardless of such “broad consensus” not having been reached.

3.62. For example, Nottinghamshire County Council carried out a waste PFI procurement exercise which ran in direct conflict with their waste strategy and without having undertaken any meaningful consultation with the local community or the waste collecting authorities. The deal was closed and the contract was signed behind closed doors without any opportunity for consensus-building (despite this shortcoming having been identified and communicated to the County Council, Defra and Partnerships UK). As a result

of the community feeling shut out of this process there was no sense of community ownership of the resulting waste contract. Instead, the County Council and their contractor (Veolia) face years of strong and effective opposition to most of the facilities that form part of Nottinghamshire's Waste PFI[8].

3.63. The extreme secrecy surrounding waste contracts runs contrary to Defra's advice to reach a broad consensus before the start of procurement. The National Audit Office observes that: "Gaining planning permission for new waste treatment facilities is a challenge for local authorities. There is often concern by residents about the nature of the facilities being proposed, resulting in objections which can cause substantial delays to the Department's programme. The Department [Defra] should encourage local authorities to consult early with residents to identify issues which residents are likely to raise"[9].

3.64. In meetings held between waste industry representatives and UKWIN we have learned that incineration and the long-term "integrated waste management" contracts associated with incineration and with the provision of waste management services by a single company are major barriers to innovation and investment in advances in recycling and reuse.

3.65. Government should offer those (including social enterprise, community cooperative and community interest companies) who are able and willing to implement entrepreneurial solutions the chance to do so by providing financial and other support, including the provision of an appropriately regulated framework, and by moving away from allowing local authorities to be locked into large-scale, long-term, inflexible waste (PFI) contracts.

3.66. An over-emphasis on funding capital expenditure (CAPEX) rather than operating expenses (OPEX) distorts the technology choice in favour of large-scale infrastructure such as incineration, and does not offer best value for money. Instead UKWIN advocates in favour of procurement processes that allow multiple small to medium sized enterprises and social enterprises to secure contracts to deliver waste services, thereby increasing competition and encouraging greater innovation.

3.67. Strategic and commercial planning for waste management at national and local levels must be based on the highest quality factual information. Government is in a unique position, and must exercise this position to ensure that useful waste data and

[8] Further details of this example can be found in the Proof of Evidence submitted to the associated public inquiry and archived at http://www.nottinghamshire.gov.uk/large-static/erf/es1144_pain_dowen_proof_of_evidence.pdf in particular at Paragraphs 154 - 158 (pages 69 – 102).

[9] National Audit Office report to Defra on Waste PFI, January_2009, available from: http://www.official-documents.gov.uk/document/hc0809/hc00/0066/0066.pdf

benchmarking information is readily available and accessible to all stakeholders throughout the public and private sectors, civil society and local communities.

3.68. The Government's strategy must institute adequate data collection as a priority and ensure that the framework provides for the necessary data collection for household, C&I and C&D streams.

3.69. The clearer we can be about the waste volumes (of all types) and the locations of these arising, the better able we will be to define and plan for infrastructure requirements.

3.70. The waste data currently available, and the models that use this data, are not always accessible to the public. All waste projections, for example, should state their assumptions, formulae, methodology, raw data, etc. There is an obvious and pressing need for waste composition analysis to ensure, for example, that waste incinerators are no longer permitted to rely on kitchen waste for their feedstock.

3.71. An applicant for a waste incinerator should have to robustly demonstrate that their proposal would not pervert the waste hierarchy over the entire lifespan of their proposed facility. This is especially important where no waste plan in place, or where circumstances have materially changed. Justification should be based on sound evidence, including waste compositional analysis, and waste trend analysis that takes account of current and future legislative and non-legislative drivers to reduce waste arisings and anticipate increases in the recyclability of waste in the future.

3.72. A distinction needs to be made between facilities that are located higher in the waste hierarchy and facilities that follow the waste hierarchy. Burning material in an incinerator that could be recycled should not be justified by recourse to the notion that incineration is somehow better than landfill. Currently, such spurious arguments are advanced for each and every incinerator application, and this serves to further stifle innovation and to further alienate community stakeholders.

3.73. **Do local authorities have the right responsibilities for waste services? Are there further services that could be devolved to local authorities or directly to local communities?** (part of Questions General 2.3)

3.74. UKWIN has formed the view that many local authorities appear to lack the appropriate skills, enthusiasm and commitment to zero waste principles for the effective, creative and environmentally sensitive management of waste services, either in-house (historically) or when these services have been contracted out to a commercial organisation. Such waste contractors are seen to

exhibit many of the same characteristics, especially the lack of vision and lack of will to enact an approach that would ever bring about zero waste to landfill and incineration.

3.75. This is not surprising when contracts are in place that prioritise making feedstock available for incinerators, and that provide greater rewards to contractors for managing larger volumes of waste. New and innovative financial arrangements, contractual flexibility, and tough targets for waste minimisation and ever-increasing recycling and reuse, are urgently required to address this problem. Current waste contracts are driving waste management down to the level of their unambitious targets.

3.76. Many Unitary and so-called Disposal Authorities (who should be re-branded “Treatment Authorities” and/or merged with Collection Authorities for waste management purposes) see their primary responsibility as the disposal of waste, and therefore display little regard to the waste hierarchy, the proximity principle, or to best environmental practise.

3.77. The Landfill Directive, the LATS system, the Landfill Tax and the fear of huge fines for exceeding biodegradable landfill allocations combine to greatly reduce the quantities of waste sent to landfill. Local authorities and waste contractors have, by and large, merely focussed on sending waste to the next rung of the hierarchy, turning to incineration as their response to landfill avoidance, rather than focussing on the higher rungs of the hierarchy to achieve zero waste.

3.78. The vast majority of Two-Tier Authorities experience an obvious and well-recognised conflict between the pressures on Collecting Authorities to collect discarded material as cheaply as possible and the interests of Disposal Authorities to preserve the value of these materials. This conflict limits the resulting quality of co-mingled waste, reducing the options for reuse, recycling and disposal (cf. Somerset’s “invest to save” policy of funding collection methods that preserve and enhance the value of discarded material).

3.79. Financial benefits of increased segregation often go to Disposal Authorities and their contractors, while the costs of such systems are largely borne by Collection Authorities and their residents. Benefits of segregation should be felt more locally.

3.80. Although superficially it would appear that local authority control over waste would increase democratic accountability, more needs to be done to make this work in practise. When local authorities are locked into secret, long-term waste contracts, there seems to be no democratic mechanism for local people to influence how their discarded materials are managed, or to ascertain whether or not they receive value for money.

3.81. Local authorities should therefore be given greater responsibility for involving local residents in waste management, within the context of the entrepreneurial framework, outlined above in Paragraphs 3.45 and 3.46.

3.82. Waste strategies in most local authorities are based on fallacious assumptions that ignore current household waste trends. Thus, local authorities proceed as if there will be a growing volume of non-recyclables ('residual mixed waste')[10].

3.83. Recycling and reuse are treated as secondary considerations for many local authorities, and waste minimisation would seem to be a tertiary consideration at best. The number of 25-year contracts being signed (in reality, on very disadvantageous economic and environmental terms) bears witness to this.

3.84. A requirement of a zero waste economy is the imaginative and committed (social) entrepreneurial exploitation of reusable potential manufacturing resources, a requirement that local authorities and their commercial contractors appear ill-equipped to fulfil.

3.85. **How can illegal waste activity be minimised, including reducing levels of fly-tipping? Are sanctions for breaches of waste regulation fair and proportionate?** (part of Questions General 2.3)

3.86. Sanctions should be such as would succeed in deterring offenders, and should reflect the extent of environmental damage caused.

3.87. Current sanctions are universally considered by UKWIN members to be far too lenient in relation to breaches of environmental permit conditions and planning conditions for waste incinerators.

3.88. UKWIN agrees with Friends of the Earth, that environmental permits for waste incinerators should be required to be revised and reviewed every five years.

3.89. In a true zero waste environment, there would be nothing to fly-tip, only resources to sort and bring back into use.

[10] We note Paras 158 and 159 of the Audit Commission's (2008) Well Disposed report: "WDAs have struggled to understand both how the underlying drivers of waste arising are changing and what effect their and others' waste minimisation initiatives will have. WDAs need to develop evidence based projections to inform their infrastructure requirements. Detailed guidance on forecasting is available from CLG (Ref. 21), but data quality and realism of projections was the weakest area in our desktop assessment of strategies, and sensitivity analysis was particularly weak… If WDAs overestimate the amount of waste they will need to process, both the overall cost and the cost per tonne of waste processed are likely to be higher than they would have been had estimates proved accurate...".

3.90. **How can we balance regulation to ensure that we protect health and the environment without unnecessarily burdening businesses and local authorities? What are the opportunities to reduce or remove the burdens of regulations?** (part of Questions General 2.3)

3.91. Environmentally-friendly processes require less regulation and monitoring than unfriendly ones. Cessation of incineration would reduce the need for regulation and thereby reduce costs.

3.92. The role of the regulator should be complemented by active citizens; therefore information gathered by industry regulators, e.g. the Environment Agency, should be made readily available to citizens, e.g. the whole of the Environment Agency's public register should be accessible via the Internet. It is currently very difficult for local communities to access relevant information, e.g. citizens are currently hampered by exorbitant charges for access to environmental permits and permit applications, annual incinerator performance reports and associated monitoring forms, etc.

3.93. Regulation plays an important role in protecting health and public interest. Regulation and the enforcement of quality standards, within the context of the framework, will benefit green businesses as it will mean more recyclables and more opportunities.

4. Waste Prevention (Call for Evidence 2.4)

4.1. Achieving the goals of both zero waste and One Planet Living requires not only higher recycling rates, but also a reduction in the quantities of waste arising.

4.2. The UK should learn lessons from other countries where waste disposal costs paid by householders and businesses correlate closely to the quantities, hazardousness and environmental impact of discarded materials.

4.3. **What roles should (i) national and local government; (ii) businesses; (iii) voluntary organisations; and (iv) individuals take in order to prevent waste from arising, and to reduce the hazardousness or environmental impact of waste?**

4.4. National Government should create a legislative, fiscal, incentive, and regulatory framework that prevents the proliferation of non-reusables and non-recyclables, and that maximises reuse, recycling and waste reduction. This approach to zero waste is already described in some detail above.

4.5. National Government should promote policies that recognise that there is a need for education to transform the perception of "waste" as being something to burn or bury. Material surplus to the requirements of its owner(s) must be seen as a resource of value to other parties.

4.6. The landfill tax should be extended to a general disposal tax that also penalises incineration.

4.7. Local Government's role should include educating householders and businesses to reduce waste arisings and maximise reuse and recycling.

4.8. Local Government should be given a role in supporting and overseeing the creation of community based cooperative franchises, whose responsibilities could cover the collection and sale of recyclables, green material for composting and food waste for AD. Local Government should be expected to provide the necessary collection infrastructure, work with partners to promote waste reduction and recycling practices to businesses and individuals, and actively support voluntary organisations in the reuse of discarded items.

4.9. Local Government should also:

4.9.1. actively engage local communities regarding waste management and planning decisions;

4.9.2. collect and supply timely and accurate waste data for general use;

4.9.3. ensure that there are appropriate waste management facilities to maximise recycling and re-use and to maximise the value of those activities;

4.9.4. co-ordinate with neighbouring authorities to avoid over-provision and to ensure that waste is dealt with at the nearest appropriate location;

4.9.5. ensure adequate planning control policies and procedures so that inappropriate waste facilities, that undermine the waste hierarchy, should be denied planning permission.

4.10. The alternate weekly collection of residual and recyclable waste should be supported and complemented by weekly collections of food waste.

4.11. Increase kerbside sorting and the use of smaller waste receptacles for residual waste[11].

4.12. Businesses are responsible for what they buy and sell. They should support minimisation, reuse and recycling initiatives.

4.13. Businesses must also accept Extended Producer Responsibility.

4.14. Voluntary organisations should support reuse, recycling and waste minimisation initiatives.

4.15. Individuals should be expected to take responsibility for their discarded materials through more responsible consumer choices, i.e. to purchase recycled and reconditioned goods, and by segregating their wastes, by recycling and composting as much as possible, by participating in community-based initiatives such as composting schemes, and by taking an active interest in relevant decision-making processes.

4.16. **What can be done to encourage businesses to design and manufacture products which produce less waste – such as**

[11] "Where it works well, alternate week collections increase the amounts recycled dramatically. 90 per cent of the top recycling councils operate an alternate week collection scheme… bizarre as it may seem, but the evidence shows that a bigger bin leads to people throwing away more waste. There is still disagreement about the actual reasoning for this, but it is undeniable that a weekly refuse collection with a large wheeled bin collects more waste than areas with smaller bins, less frequent collections or on a (smaller) traditional bin." Source: http://www.letsrecycle.com/resources/doc/news/Waste_Management_Quick_Guide.pdf

those which last longer, can be upgraded and/or repaired, and don't have hazardous components? How might Responsibility Deals contribute to this?

4.17. Introduce consumer protection legislation to extend requirements for manufacturers and retailers to replace or repair faulty electrical goods to encourage manufacturers to make products that last longer and retailers to only stock more long-lasting products.

4.18. Introduce measures to promote public, manufacturer and retailer awareness of such legislation, and support individuals to exercise their rights.

4.19. Consider encouraging the provision of white and similar goods on a rental contract with service support basis, so that for example instead of buying a washing machine for £500 once every five years customers pay the manufacturer for a service that for £100 a year guarantees a working washing machine in an ongoing contract. We recognise that such an approach could result in unintended consequences, e.g. the above manufacturer may be tempted to replace the washing machine to avoid repair costs, or to gain competitive advantage for their service, and this could actually increase waste.

4.20. Producers, and distributors, will have to work within the proposed framework and accept and comply with the principles of Extended Producer Responsibility. They must understand and accept the consequences of their actions. A key issue here is recyclability and reusability of component parts, as well as product duration. Some hazardous components are inevitable but that does not in itself preclude recycling or reuse.

4.21. The principles of the Producer Responsibility Obligations (Packaging Waste) Regulations, and Producer Responsibility Notes (PRNs) represent an example of Extended Producer Responsibility. Within this context incineration should not be treated as recovery.

4.22. Sending recyclable and reusable material for incineration should be seen as irresponsible within the context of producer responsibility.

4.23. **Which waste streams or materials should be a priority for waste prevention?**

4.24. Materials that cannot readily be reused, recycled or composted should be phased out of use.

4.25. Priority for waste prevention should be given to those materials with greatest environmental impacts.

4.26. Promote home composting by making waste reduction a priority over increased composting by local authorities. It should be noted that waste arising figures have been distorted by the introduction of garden waste collection services by local authorities whose primary aim was to flatter their recycling and composting rates.

4.27. **How should waste prevention be measured?**

4.28. By monitoring surplus (residual waste) material arisings at households and businesses.

4.29. Another metric could be the amount spent on waste prevention education, although quality control measures would need to accompany this to ensure money is not wasted on poor quality, ineffective education.

5. **Preparing for Reuse** (Call for Evidence 2.5)

5.1. **What more do you think Government, businesses and civil society could do to increase activities that prepare waste for reuse?**

5.2. Government should encourage reuse developments with business start up incentives. Discuss with manufacturers the potential for (and barriers to / issues with) 'factory reconditioned' or 'upgraded' units'. This approach could fit with Extended Producer Responsibility.

5.3. The overall macro effects of expanding reuse should be examined. It might, by making available consumer goods at lower than new prices, enable a higher actual living standard for consumers and margins for commercial organisations as well as reducing the burdens of Extended Producer Responsibility for manufacturers.

5.4. Manufacturers should be discouraged from producing products that seek to prevent reuse and repair, e.g. ink cartridges and printers that are designed to hamper ink refilling, and electronic goods with batteries that are not user-replaceable.

5.5. Ambitious reuse targets should be introduced into all integrated waste management contracts.

5.6. Businesses should prepare, offer and advertise the availability of competitively priced pre-owned products, and guarantee the continued availability of spare parts, e.g. for 20 years.

5.7. Civil Society should seek to purchase pre-owned products rather than new ones, and this should be reflected in public procurement procedures.

5.8. **Which waste streams or products are priorities for reuse?**

5.9. Glass (bottles) and electrical goods.

5.10. The principle of reuse tends to cut across the established consumer culture and the economic implications of it. Markets already exist for some types of item, such as motor vehicles, some white goods, some computer components and houses, as well as industrial plants and machinery and office equipment. For others, such as furniture and toys, the voluntary sector can provide and is providing an answer.

5.11. An issue with electrical goods is safety and the availability of spare parts, and it is often cheaper (financially) to replace with new rather than to repair them.

5.12. Many component parts are not manufactured to be repairable. They are nominally made to last the life of their “parents”, and it is not practicable to repair them. We come back to recyclability and the fact that in many cases, recycling is commercially preferable to reuse and indeed the only current practical solution. With appropriate changes in product design policy this situation could be expected to change.

5.13. Notwithstanding this, it is frequently possible to procure spares from alternative sources and those with the relevant entrepreneurial ingenuity should be encouraged to develop reuse businesses.

5.14. There is also the aspect of conditioned attitudes – many people would not currently ‘expect’ to buy used items other than, perhaps cars, houses and, sometimes, furniture. With computer goods, the rate of technical advance limits the market for reused items.

5.15. Encouragingly, E-Bay, Amazon, Freecycle, and other similar on-line trading organisations have succeeded in stimulating new demand for the reuse of (second-hand and nearly-new) products.

5.16. **What are the existing barriers to preparing more waste for reuse from both the household waste stream and the ‘Commercial and Industrial’ and ‘Construction and Demolition’ waste streams?**

5.17. There is currently a regrettable shortage of suitable infrastructure for the collection and redistribution of reusable items.

5.18. The need to provide feedstock for incinerators is proving a barrier to reuse (see also Para 3.64 above).

5.19. The availability of data for C&D and C&I wastes is poor. Such data as there is for C&I suggests that volumes generally are falling and that there is great scope for improving recycling and reuse levels within both business and public sectors.

5.20. In many cases, in relation to the commercial and industrial sector, the situation and the barriers are similar to those affecting householders. Moreover, most businesses will not perceive that they are, or want to be, in the business of preparing items for reuse. If specialist reuse businesses were to be promoted, and some exist now (e.g. for office furniture), reuse would increase. Obsolescence will restrict opportunities for reuse in some cases. The reuse of assets (plant and machinery) is probably much more established in industry than elsewhere. Similarly, markets for some

demolition materials, such as girders and building stone, already exist.

5.21. We therefore return to noting the importance of encouraging entrepreneurs and enterprising communities to set up reuse businesses.

5.22. **Who is best placed to deliver an increase in reuse? How could civil society take a role?**

5.23. Government must create the appropriate entrepreneurial incentives within the framework proposed.

5.24. Civil society, particularly if reuse saves money, could be expected to play a greater role in promoting awareness of the availability of reuse organisations and the opportunities to purchase items prepared for reuse.

6. **Recycling** (Call for Evidence 2.6)

6.1. *Serious about recycling?*

6.2. Practices, such as incineration of valuable resources, act as barriers to recycling by diverting recyclables and by perpetuating the cynical concept of waste disposal, and therefore should cease.

6.3. Subsidies that support incineration, via PFI or otherwise, must cease. Government should incentivise developing markets for recyclables. Recycling businesses, community cooperatives and otherwise, need to be encouraged.

6.4. Many are willing and even eager to recycle more, but they find themselves unable to do so because of the lack of recycling provision. Government should therefore do its utmost to make it as easy as possible to recycle the widest possible range of materials.

6.5. The principles of maximised recycling and up-cycling imply that quality recyclable material will be made available to product manufacturers. Currently, the quality of recyclables is severely damaged by commingled collections.

6.6. Markets for recyclables need to be developed, and changes need to be made to do away with the practices that act as barriers to recycling, practices such as favouring incineration in PFI, and other Government funding and subsidies that support incineration. Recycling businesses, community cooperatives and otherwise, need to be encouraged.

6.7. *Incineration and recycling – the evidence*

6.8. There is a wealth of evidence that incineration is incompatible with, and works directly against, a high recycling strategy.

6.9. UKWIN refutes the notion that high recycling and high incineration can be seen as compatible. Incineration is in fact a barrier to high recycling. The idea that one could have both high recycling and high incineration is a contradiction in terms.

6.10. With some 70% of household waste considered by the Audit Commission (2008, Well Disposed, Para 140) to be "readily recyclable" (and at Para 47 it is noted that 70% of MSW is biodegradable, and would therefore be suitable for composting / AD), and with the Welsh Assembly Government's study demonstrating that 93.3% of discarded materials could be recycled or composted[12], it is apparent that high incineration rates can only come at the expense of recycling and composting.

[12] http://wales.gov.uk/docs/dsjlg/meetings/090106pc304annex2e.doc

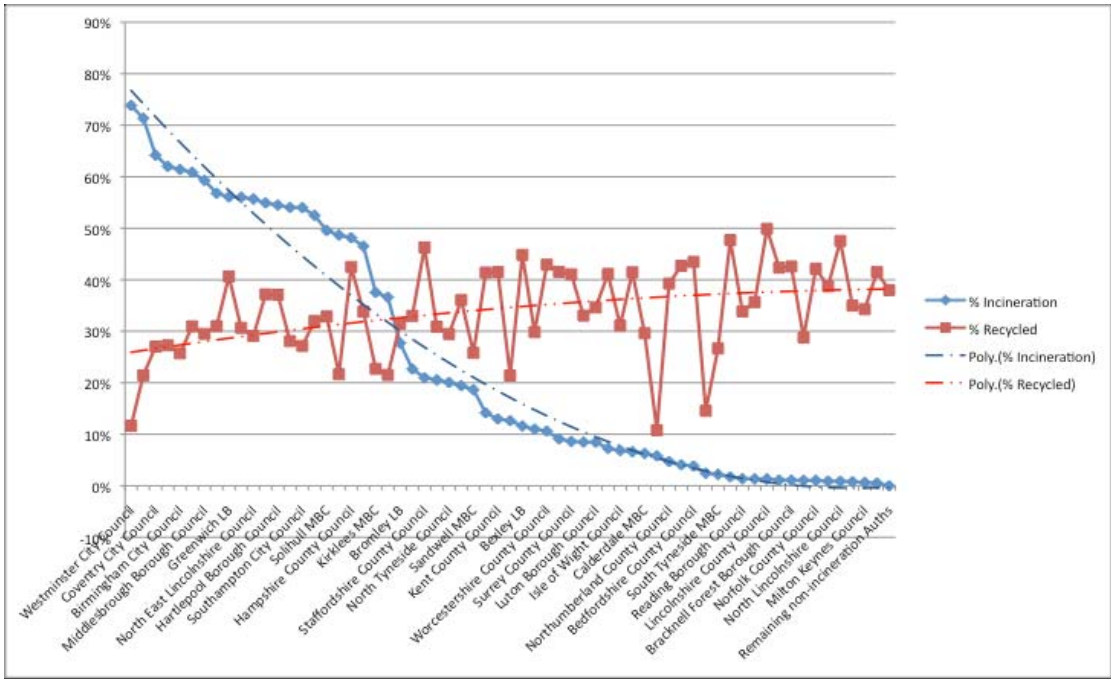
6.11. Whilst 6.7% of the current waste stream may not be recyclable that does not mean that it is combustible and due to waste minimisation efforts the quantity of such waste should be expected to decrease in real terms. In fact, in a zero waste strategy this non-recyclable waste should be a top priority for waste minimisation efforts and should not be used to justify waste incineration.

6.12. An assessment of the 2009 MSW statistics published by DEFRA shows how none of the top 5 incineration authorities rank in the top 100 recycling authorities:

	Rank Incineration	% Incineration	% Recycled	Rank Recycling	% Landfill	Rank Landfill
Westminster City Council	1	74%	12%	120	15%	108
Lewisham LB	2	71%	21%	116	7%	118
Coventry City Council	3	64%	27%	104	9%	115
Portsmouth City Council	4	62%	27%	102	11%	113
Birmingham City Council	5	61%	26%	109	13%	110

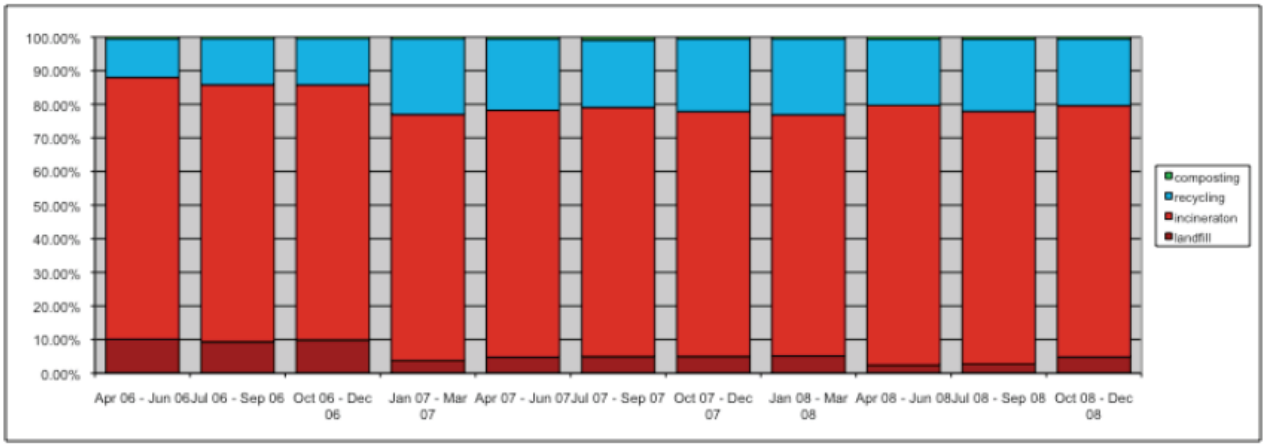
Source:
http://www.defra.gov.uk/evidence/statistics/environment/wastats/bulletin09.htm

6.13. Although the data includes some variability it is clear that there is a general inverse correlation between incineration and recycling:

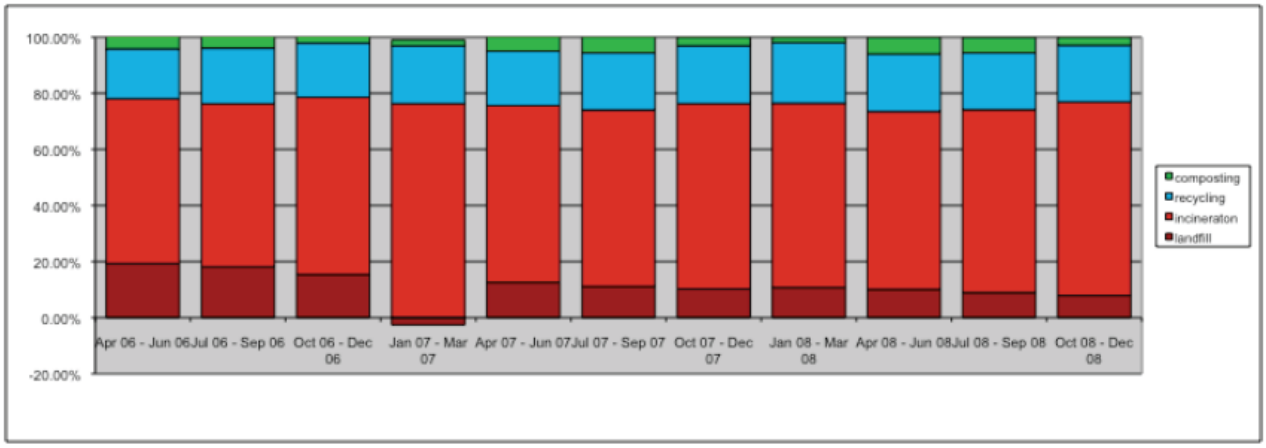


6.14. There is increasing hard evidence that higher levels of incineration undermine recycling. This is not surprising as incinerators rely particularly on paper and plastic waste to provide the homogenous waste stream with a stable calorific value that is necessary to achieve stable combustion.

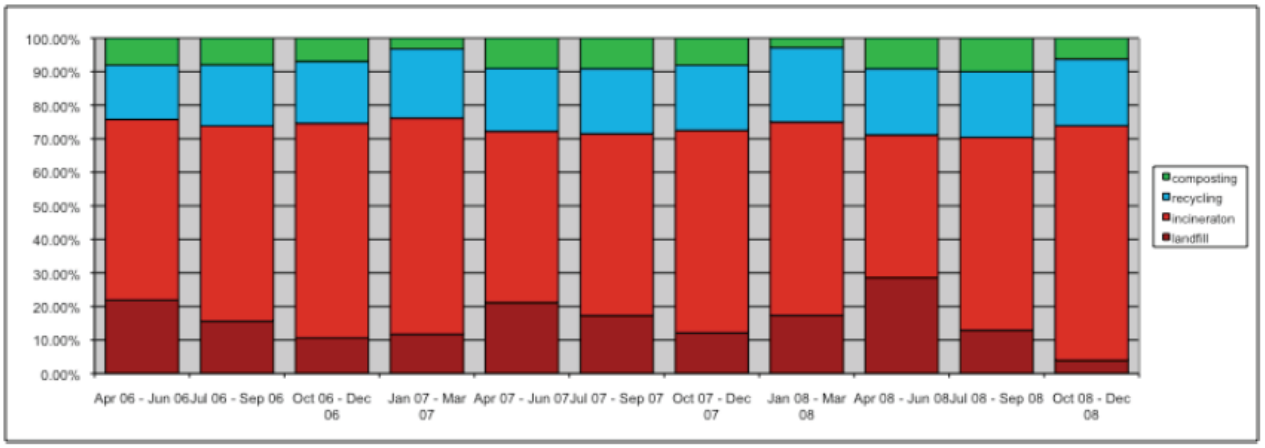
6.15. In Lewisham, for example, Veolia's (inaccurately named) South East London Combined Heat and Power plant (which fails to harness the heat), and the contract with the local authority has resulted in very low local recycling levels:



6.16. A similar situation with poor recycling rates arises in Portsmouth where Veolia has another incinerator:



6.17. Even Sheffield, one of the original "*recycling cities*" of the early 1990's has ground to a halt and needs to dramatically reduce the proportion of waste incinerated if even the recycling targets in WS2007 are to be achieved:



6.18. It can be seen from the above that the incineration rate in each case rose to about 70%. In each case future growth of recycling is severely constrained and incineration will need to reduced - this is likely to involve contractual penalties in each case although in principle reducing the levels of incineration and increasing recycling should reduce total costs based on the data from the

Waste & Resources Action Program (WRAP) 2009 report showing incineration to be the most expensive treatment:

Summary information on gate fees

Treatment	Grade / material / type of facility	Median[1]	Range
MRF	Cans/plastic/paper/card	£24	£6 - £50
Composting	Open-air windrow (OAW)	£23	£12 - £49
	In-vessel (IV)	£38	£15 - £70
	Anaerobic Digestion[2] (AD)	£52	£40 - £65
Landfill	Gate fee only	£22	£8 - £42
	Gate fee plus landfill tax[3]	£54	£40 - £74
Incineration	All facilities[4]	£68	£24 - £141
	Post-2000 facilities	£83	£68 - £141
MBT		£62	£42 - £82
Wood reprocessors[5]	Grade A	£20	£0 - £45
	Grade B	£31	£25 - £38
	Grade D	£35	£25 - £47

6.19. The cost information indicates that in the absence of long-term contracts waste would tend to be recycled rather than incinerated. Because capital costs for incinerators are high, in order to ensure they make a return on their investment, operators need a guaranteed payment over a long period. To provide finance, lenders require operators to secure contracts that ensure waste is available as feedstock over the life of the loan. This creates a major barrier to increasing recycling.

6.20. It is often claimed that there is no evidence that incineration competes with recycling for waste. In reality, there is of course a link – there is only so much waste available, so the amount processed through all treatment techniques must add up to 100% of the waste. Regional data for household waste in 2005 from Denmark, often claimed to be an exemplar for incineration, clearly shows that regions with high incineration have lower recycling:

Region	*Recycling*	*Incineration*	*Landfill*
Hovedstaden	21%	77%	2%
Nordjyllnad	29%	63%	8%
Sjælland	31%	59%	10%
Midtjylland	40%	53%	7%
Syddanmark	41%	52%	6%

6.21. The comment in Waste Strategy for England 2007 that "evidence from neighbouring countries, where very high rates of recycling and energy from waste are able to coexist, demonstrates that a vigorous energy from waste policy is compatible with high recycling rates" is incorrect. As recently reported by The Independent on Sunday "Gill Weeks, of the Environmental Services Association, the trade body representing the UK's waste

management industry, claimed there was particular overcapacity [of incineration] in Germany and the Netherlands, with other EU member states exporting waste there"[13].

6.22. A study by the Zero Waste New Zealand Trust[14] reported that thermal conversion technologies need a constant supply of materials, often with a high fuel value (like paper and plastics), which can shift the focus away from recycling programs. The study stated that developing thermal conversion technologies can "*result in the creation of long-term contractual agreements with local authorities guaranteeing a certain tonnage of waste per year. This situation effectively destroys incentives for local decision-makers to minimize waste or lead resource recovery programs*."

6.23. The Guardian newspaper[15] reported that East Sussex County Council is "*so worried it may not be able to fulfil its contract that it has now capped Lewes and Wealden's recycling levels - effectively penalising them if they recycle more than about 30% of their waste*". The incinerator would be operated under a contract with Veolia.

6.24. MP Norman Baker raised the issue in Parliament[16] saying: *"The Government rightly promote recycling, but is the Minister aware that Lewes district council's recycling levels have effectively been capped at 27 per cent by East Sussex county council, which will not provide further recycling credits because it wants a waste stream to feed its incinerator? Is it not about time that East Sussex county council was pulled out of the stone age and that councils that want to recycle more, such as Lewes council, which believes it can increase recycling by 50 per cent., were allowed to get on with it?"*

6.25. The Inspector considering the Ridham Dock Incinerator application (Secretary of State 2002) concluded that if permission were granted the "*provision of greater incineration capacity than necessary would tend to undermine efforts to increase waste recycling and recovery locally, and encourage the transportation of waste from a more widespread catchment area*".

6.26. As the Audit Commission's Well Disposed report[17] states: "WDAs might buy too much disposal infrastructure if they overestimate future volumes of waste arising (including other authorities' waste or trade waste). They may also achieve a worse

[13] UK may have to import rubbish for incinerators, 1st August 2010
[14] Zero Waste New Zealand Trust, *Wasted Opportunities – A Closer Look at Landfilling & Incineration*, http://www.zerowaste.co.nz/default,33.sm
[15] John Vidal, 9th August 2006, Ecosoundings: Burning issue
[16] Hansard 2 July 2009: Column 477
[17] http://www.audit-commission.gov.uk/reports/NATIONAL-REPORT.asp?CategoryID=ENGLISH-576-SUBJECT-397&ProdID=C0CDCBFE-24E0-494d-824D-F053A576661E

environmental solution if, by building large disposal facilities, they reduce their own financial incentive to pursue waste reduction or recycling initiatives" (Para 151, pp 77-78).

6.27. The Government needs to learn from the experience in Kent where it is reported that "…what was initially seen as a cash-saving opportunity has quickly turned into a money pit, as the council is forced to send increasingly valuable recyclable material to the incinerator in order to meet its annual quota". Kent County Council's Environment Spokesman said of the decision to sign a long-term incineration contract: "What seemed a very wise decision a very long time ago is a very stupid one today…"[18].

6.28. Returning to the Audit Commission's Well Disposed report (at Para 160) we read that: "One of the common objections to Energy from Waste (EfW) facilities is that after they have been built they will discourage further improvements to recycling because the facility is designed to process a fixed amount of waste (between an upper and lower limit). WDAs therefore need to build ambitious forecasts for recycling and waste minimisation into business cases for disposal infrastructure if they are to avoid creating such a disincentive."

6.29. The EFRA Committee report[19] records Dr Paul Leinster, Chief Executive of the Environment Agency as saying: **"**The objective for me would be that you should not have an incinerator which then destroys waste minimisation programmes or interrupts re-use and recycling".

6.30. In answer to the question: "…This has been built by means of a 25 year PFI. During the 25 years and in the next 25 years the way that we dispose of our waste will change radically. I do not think in 25 years' time there will be enough waste to feed this incinerator. Is that a concern of yours?" Dr Leinster replied: "Absolutely. What we should not be doing is having incinerators which then mean minimisation, re-use, recycling get impacted and that has to be over the 25 year period. I do have concerns over locking technologies in on a 25 year basis when technologies are moving as fast as they do".

6.31. According to the Local Government Improvement and Development organisation (formerly known as I&DeA): "There is a danger that investing in large, inflexible EfW incineration facilities as a technical fix to divert waste from landfill can undermine efforts to prioritise minimisation and recycling".

6.32. The EFRA Committee's report praises householders for increasing their recycling levels to nearly 37% and urges the

[18] Kent's waste contract could be money in the bin, 12th August 2008 http://www.kentonline.co.uk/kentonline/newsarchive.aspx?articleid=46264

[19] http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenvfru/230/230ii.pdf

Government to set tougher recycling targets of 50% by 2015 and 60% by 2020. However, the fact that 15 District Councils exceeded 52% recycling levels in 2008 / 2009 suggests that these targets are unambitious.

6.33. We agree with EFRA Com that Government should require local authorities to provide all householders with information each year on what happens to the waste they put out for recycling. Councils must explain clearly to people what it costs to collect and dispose of each bin, bag or wheelie bin of waste.

6.34. The MPs call for the Government to, amongst other things, "Set a target for mandatory collection of food waste, learning lessons from those authorities which already collect such refuse for beneficial use such as in anaerobic digestion plant, and ensure continued provision of advice, education and practical support, for example through reduced cost composting equipment".

6.35. **What should the role and nature of local authority waste management collection and disposal services be?**

6.36. The role of local "waste management" collection and disposal services should be to maximise the collection and sale, on an entrepreneurial basis, of segregated, high quality, recyclables, garden waste and food waste. These services might best be performed by local community cooperative organisations.

6.37. **How can individuals, businesses and communities best be motivated to recycle more?**

6.38. There is a need to ensure that waste contracts result in rewards for increased recycling, and ensure that benefits are returned primarily to local communities to allow local people to feel the benefits. Profits from recycling should be shared at the most local level.

6.39. UKWIN notes that reward schemes could result in perverse outcomes, such as incentivising recycling over reduction.

6.40. Individuals, businesses and communities must be confident that their recyclables will actually be recycled into new products, and not incinerated or landfilled. Access to factual data that shows the steady progress being made towards zero waste is needed to help convince people and organisations of the overall benefits to society of recycling.

6.41. **How does the choice, including frequency, of collection service impact on the quantity and quality of waste fit for recycling?**

6.42. The quality of recyclables depends in very large measure on source segregation. For example, glass shards contaminate paper that would otherwise be bound for recycling if these are mixed (commingled).

6.43. Food waste should be segregated and collected weekly, as this would supply AD plants with suitable material.

6.44. **Should greater emphasis be placed on using recyclable / recycled materials in manufacturing and production and, if so, how should this be achieved?**

6.45. Yes, by taxing virgin materials, and by internalising the externalities. See the Friends of the Earth briefing entitled From Waste to Resource[20].

6.46. Public procurement should favour the purchase of recycled and reused, recyclable and reusable products.

[20] http://www.foe.co.uk/resource/briefing_notes/waste_to_resource.pdf

7. Energy Recovery (Call for Evidence 2.7)

7.1. Before responding to the Government's question there are several general points to be made about energy recovery as this term is used to refer to waste incineration.

7.2. *Environmental issues*

7.3. For comparative analysis of the GHG-related performance of different technologies for energy recovery the totality of the CO2 implications (biogenic and non-biogenic) of all the processes within the life cycle(s) involved must be taken into account, not just those for the energy recovery plants themselves.

7.4. UKWIN notes that the WRATE (Waste and Resources Assessment Tool for the Environment) modelling software used to assist Life Cycle Analysis (LCA) ignores biogenic carbon and produces flawed results. See Appendix B for A Critique of WRATE.

7.5. Incinerators are associated with the unintended creation of persistent organic pollutants (POPs). In correspondence with the Environment Agency (EA) they have made it clear that planning authorities have a responsibility to honour the UK's commitment to the Stockholm Convention and the obligations under the 2007 Persistent Organic Pollution Regulations to give priority consideration to alternatives to incineration that do not give rise to persistent organic pollutants ("Annex III substances").

7.6. Despite the EA's clearly-stated position[21], UKWIN has seen no evidence to demonstrate that local authorities are either qualified or willing to meet these responsibilities. Indeed, we have a wealth of evidence that shows that local authority planning officers routinely insist that the entire responsibility for POPs rests solely with the EA. In the event no authority takes proper responsibility for the UK's compliance with the laws regarding the avoidance of unintended POPs.

7.7. UKWIN therefore calls upon the Government to issue clear guidelines to both planning authorities and the Environment Agency spelling out their respective roles and responsibilities in relation to implementing the UK's POPs obligations.

7.8. The Sustainable Development Commission applies the following criteria to EfW incineration[22]:

[21] For example, in legal correspondence to the Hull-based anti-incineration campaign group known as HOTI, the EA said: "The encouragement of recycling and promotion of alternative waste management solutions within a particular area are matters for local waste planning authorities and the Secretary of State, not for the Agency" (2nd December 2009).
[22] See http://www.idea.gov.uk/idk/core/page.do?pageId=9594626

7.8.1. no waste should be thermally treated unless separation of recyclables has taken place first;

7.8.2. EfW systems need to be evaluated on their ability to reduce overall carbon dioxide (CO2) emissions - schemes need to be developed in accordance with the proximity principle;

7.8.3. the scale and technology used should be flexible;

7.8.4. planning for any EfW facility must only take place after proper engagement and consultation of local communities.

7.9. Despite this wise counsel, such considerations are often ignored.

7.10. UKWIN also notes the EFRA Committee's assertion that: "Waste should only be used for energy recovery if it is not possible to re-use, recycle or compost it. To achieve maximum energy efficiency levels, planning consent for energy from waste plants must require heat to be captured and used".

7.11. Sadly, this advice is also ignored.

7.12. Incinerators emit particles including nanoparticles. There is widespread concern amongst scientists over the medical risks that accompany the spread of these particles, both in general and, specifically arising from incineration processes. High temperature combustion processes such as incineration generate nano-particles with metallic, dioxin and aromatic hydrocarbon (PAH) coatings that may be very damaging to health. The review by Cormier et al (Origin and Health Impacts of Emissions of Toxic By-Products and Fine particles from Combustion, 2006) is strong evidence, supported by emerging research establishing tangible public health impacts (Univ. of California study 2008 – Air Pollution may Cause Heart Disease; shows nano-sized particles are the most damaging).

7.13. International POPs Elimination Network's Nanotechnology Working Group Workshop on nanomaterials organised in Abidjan (January 2010) produced a brief background document on nanotechnology and nanomaterials[23].. This document includes the following: "The United Kingdom's Royal Society, the world's oldest scientific institution, has recommended that given the emerging evidence of serious nanotoxicity risks, nanoparticles should be subject to new safety assessments prior to their inclusion in consumer products…and the release of nanoparticles into the environment should be avoided as far as possible...Swiss Re, one of

[23] http://www.ipen.org/ipenweb/work/nano/ipennano%20abidjan%20background.pdf

the world's largest reinsurance agents, has warned that 'the precautionary principle should be applied whatever the difficulties'…".

7.14. *Economic issues*

7.15. There are sound economic arguments against waste incineration. Although it is not appropriate to comprehensively cover all of these arguments in this submission, UKWIN wishes to make several points about the economics of incineration. The costs of incineration can be grouped into:

7.15.1. Cost of opposition, i.e. costs arising from delays, public inquiries, resources required to defend planning applications, costs arising from the failure to secure planning permission, and associated threats by waste companies to walk away from waste contracts, leaving local authorities without waste infrastructure, unless more money is paid to contractors;

7.15.2. Cost of excess capacity, resulting in high costs both per tonne and overall, e.g. the payment of availability fees for incinerators even when the facility is not required as waste arisings are often less than anticipated and recycling rates are often higher than expected;

7.15.3. Landfill tax subsidy costs;

7.15.4. Environmental costs, e.g. GHG emissions;

7.15.5. Opportunity costs, i.e. burning valuable materials that might otherwise have been reused, recycled or composted, or even stored for future recycling; and

7.15.6. Construction, maintenance and enhancement costs, e.g. payments to contractors for architectural enhancement to proposed waste incinerators.

7.16. UKWIN calls Defra's attention to Veolia's threats regarding their Newhaven incinerator, made in 2007, when the risk that their costs could increase, Veolia offloaded that risk onto the Council[24]. This is linked to a statement made in the Audit Commission (Well Disposed, 2008) that: "Some WDAs [Waste Disposal Authorities] have found that they continued to bear risks they thought they had allocated to a contractor. Such risks include planning delays and technology failures—contractors were able to ensure the WDA bore the risk by threatening to walk away from the contract, leaving the WDA without waste disposal infrastructure".

[24] See the Argus article "Incinerator's Cost Doubles", Brighton Argus, 28th Sep 2007, http://www.theargus.co.uk/news/1720827.incinerators_cost_doubles/

7.17. The Brighton Argus newspaper reported that: “The construction costs of a controversial incinerator project have more than doubled from original estimates…Veolia claimed that the waste contract, agreed four years ago, was no longer profitable and would have to be extended by five years…Under the contract Veolia is liable for all increased costs to the project but councillors feared that without help the contractor would go bankrupt causing the project to collapse. Veolia faces a rise in construction costs from £71.7 million to £145.7 million. The longer contract will give Veolia an extra £35 million in income. Councillors feared that if they refused to extend the contract Veolia would walk away”.

7.18. For another example of the bad value for money that waste contracts often represent, UKWIN draws attention to Shropshire. Campaigners in Shropshire obtained the payment schedules for their Veolia waste PFI contract using Section 15 of the Audit Commission Act.

7.19. Schedule 7a of the Shropshire waste PFI contract contains details (reproduced below) showing the annual utility payment for the incinerator before the effect of adding inflation. It shows a £10.8 million fixed charge each year. It also shows the rebate for landfilling or burning less waste (reproduced below) which is £63.10 per tonne before the incinerator is operational and £12 per tonne saving should the incinerator become operational. Unused incinerator capacity is in effect charged at £108 per tonne while used capacity costs £120 per tonne.

	Treatment Volume Adjustment (£ per Tonne)	
from	2007/2008	Planned WTF Commencement Date
to	Planned WTF Commencement Date	2032/33
VT_{RU}	£63.10	£12.00
VT_{RL}	£63.10	£12.00

Year ended 31 March	WTS Charge (AnWTS) In Real terms (£)
2008	
2009	
2010	
2011	
2012	
2013	
2014	10,845,729
2015	10,695,009
2016	10,776,955
2017	10,796,280
2018	10,796,280
2019	10,796,280
2020	10,796,280
2021	10,796,280
2022	10,796,280
2023	10,796,280
2024	10,796,280
2025	10,796,280
2026	10,796,280
2027	10,796,280
2028	10,796,280
2029	10,796,280
2030	10,796,280
2031	10,796,280
2032	10,796,280
2033	10,796,280
2034	10,796,280
2035	6,412,929
	231,863,662

7.20. The payment mechanism shows that Shropshire will receive a royalty payment of 80% of the third party income that Veolia generates from selling spare capacity. For example if the plant had 10,000 tonnes of spare capacity, of which 80% was used for third party waste, then the royalty would appear to be £512,000[25].

7.21. That capacity would have cost the council taxpayer £1.2 million (1/9th of the utility charge).

7.22. It can therefore be concluded that the PFI incinerator contract is based on a massive fixed charge and a very low marginal charge.

[25] $R = (NCW_{TR} – (NCW_T \times VT_{RU} \times I_{RPIX})) \times 80\% + R_{CRS}$
$R = (80\% \times 10000 \times £80 – (NCW_T \times VT_{RU} \times I_{RPIX})) \times 80\% + R_{CRS} = £512,000$
NCW_{TR} Veolia income from burning third party waste
NCW_T = Non-contract waste treated (in tonnes) at the waste treatment facility in the relevant contract year
I_{RPIX} = RPIX indexation
VT_{RU} = The Volume adjustment for upper band - that is the £12 Shropshire would have received for unused capacity (which is indexed)
R_{CRS} is other royalty payments
The value of $(NCW_T \times VT_{RU} \times I_{RPIX})$ has been ignored as marginal for the purposes of this calculation and the R_{CRS} is other 3rd party income and therefore not relevant

For Shropshire the fixed cost is 10 times the marginal cost for capacity that is not used, meaning every extra tonne recycled may only save the council £12 as the council has to pay £108 for the unused incinerator capacity in any case.

7.23. In yet another example of public finance going to support incineration, it is clear that the current lower rate of taxation for incinerator bottom ash (IBA) represents a significant and unjustified subsidy to incineration with no environmental benefits. The inflexibility of incineration undermines efforts to move waste up the waste hierarchy by diverting resources from recycling, reuse, reduction, and anaerobic digestion.

7.24. There is increasing evidence that a significant proportion of incinerator bottom ash should now be regulated as hazardous waste in any case – largely due to the high levels of lead and zinc compounds the ashes contain[26].

7.25. Veolia estimate that 40% of bottom ash samples would be ecotoxic[27] using the adopted methodology from Hazardous Waste Technical Guidance WM2. In fact the real proportion should be much higher because Veolia's calculations appear to be based just on the total mass of the relevant metals whilst the formula is based on the total mass of the relevant compounds.

7.26. There is not, and never has been, any environmental reason to give incineration any level of subsidy. More recently the European Commission's thematic strategy on waste prevention and recycling noted that "*at low energy efficiencies incineration might not be more favourable than landfill*"[28].

7.27. This conclusion is supported by a large body of literature showing that the external costs of thermal treatment are actually very similar to those for landfill. Studies finding similar results include, but are not limited to: Eunomia, A Changing Climate for Energy from Waste?, Final report for Friends of the Earth, 03/05/2006; Rabl, A., J. V. Spadaro, et al. (2008). "Environmental Impacts and Costs of Solid Waste: A Comparison of Landfill and Incineration." Waste Management & Research; Holmgren, K. and S. Amiri (2007). Internalising external costs of electricity and heat production in a municipal energy system." Energy Policy 35(10): 5242 - 5253; Eshet, T., O. Ayalon, et al. (2006). "Valuation of externalities of selected waste management alternatives: A

[26] Confusion over status of incinerator bottom ash, ENDS 410, March 2009.
[27] Veolia Environmental Services (2007). Response to the Environment Agency Consultation on the Hazardous Waste-Technical Guidance WM2-Appendix C14 (Ecotoxic) 11 October 2007.
[28] Communication From The Commission To The Council, The European Parliament, The European Economic And Social Committee And The Committee Of The Regions, Taking sustainable use of resources forward: A Thematic Strategy on the prevention and recycling of waste (December 2005).

comparative review and analysis." Resources, Conservation and Recycling 46(4): 335 - 364; HM Customs & Excise (2004). "Combining the Government's Two Health and Environment Studies to Calculate Estimates for the External Costs of Landfill and Incineration, December 2004."; Turner, G., (Enviros Consulting), D. Handley, (Enviros Consulting), et al. (2004). Valuation of the external costs and benefits to health and environment of waste management options Final report for DEFRA by Enviros Consulting Limited in association with EFTEC, DEFRA.

7.28. An independent study by Dijkgraaf[29] concluded: "The net private cost of WTE (waste to energy) plants is so much higher than for landfilling that it is hard to understand the rationale behind the current hierarchical approach towards final waste disposal methods in the EU (European Union). Landfilling with energy recovery is much cheaper, even though its energy efficiency is considerable lower than that of a WTE plant."

7.29. This conclusion is similar to that reached by the OECD[30] following their review of waste Management in the UK and the Netherlands: "In both countries, there is currently a strong preference given to incineration compared to landfilling of waste – as reflected e.g. in the landfill taxes they apply. A similar preference underlies the Landfill Directive of the European Union, which fixes upper limits for the amounts of biodegradable waste member states are allowed to landfill. However, estimates in both countries indicate that the environmental harm caused by a modern landfill and a modern incineration plant are of a similar magnitude, while the costs of building and operating an incinerator are much higher than the similar costs for a landfill. Hence, the total costs to society as a whole of a modern incinerator seem significantly higher than for landfilling which indicates that some reconsideration of the current preference being given to incineration could be useful."

7.30. And: "Analyses of the negative environmental impacts of landfilling and incineration in both countries suggest, however, that the foundation for the present preference for incineration is questionable from the point of view of total social costs".

7.31. Incineration creates very few jobs and the net effect is to take revenue out of the local economy. Most of the engineering is foreign and the operators are multinationals.

[29] Dijkgraaf, E. and H. R. J. Vollebergh (2004). "Burn or bury? A social cost comparison of final waste disposal methods." Ecological Economics **50**(3-4): 233-247.
[30] Organisation for Economic Co-operation and Development (OECD) (2007). Instrument Mixes Addressing Household Waste, Working Group on Waste Prevention and Recycling, ENV/EPOC/WGWPR(2005)4/FINAL 02-Feb-2007 Environment Directorate Environment Policy Committee.

7.32. UKWIN cites the following statement by the Policy Exchange to support our call for an incineration tax: "By introducing taxation on incineration a clear preference is signalled to reduce, reuse, recycle or compost where possible."[31]

7.33. Whilst UKWIN opposes the introduction of any new incinerators, we agree with and would like to reiterate the recommendation of the House of Commons Environment, Food and Rural Affairs Committee[32] that: "Waste should only be used for energy recovery if it is not possible to re-use, recycle or compost it. To achieve maximum energy efficiency levels, planning consent for energy from waste plants must require heat to be captured and used".

7.34. Claims in planning applications for waste incinerators that C&I waste would be used to top-up an incinerator, in the event of a shortfall of municipal waste, should be required to be supported by robust evidence showing that there would be sufficient waste of a suitable composition and that its use as incinerator feedstock would not undermine C&I recycling/re-use/reduction/AD throughout the anticipated lifetime of the proposed facility.

7.35. We note that in Sheffield, Veolia's consultants were asked to respond to a series of questions within the context of Veolia's application to vary an existing planning condition placed on Veolia's Sheffield incinerator[33]. Sheffield City Council asked: "When the original application was considered the incinerator capacity was tested against higher recycling rates, up to 45%. It was argued that if this were to occur the capacity gap could be filled with up to 80,000 tonnes of commercial waste. It is now being argued that this level of commercial waste is a problem". Veolia responded that: "The composition commercial wastes today do not reflect the circumstances which prevailed in 2001".

7.36. **What are the barriers to delivering an increase in EfW capacity, including a huge increase in generation from anaerobic digestion? How might these be addressed?**

7.37. Barriers arise in major part from the ongoing attempts to secure planning permission for incinerators, viewed by many as an unacceptable form of Energy from Waste. Indeed, based on the efficiency formula included in the Revised Waste Framework Directive, these plants do not necessarily qualify as energy recovery facilities and would therefore remain within the waste

[31] Policy Exchange, A Wasted Opportunity: Getting the most out of Britain's Bins, 20th July 2009, available from: http://www.policyexchange.org.uk/images/publications/pdfs/A_wasted_opportunity_1.pdf

[32] From their report on Waste Strategy 2007, available from http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenvfru/230/230i.pdf

[33] Source: Letter from Standen to Sheffield City Council dated 13 May 2008 http://www.nottinghamshire.gov.uk/large-static/erf/pa50_letter_from_standen_to_sheffield_city_council_dated_13_may_2008.pdf

disposal category. The public perception and the reality of these incinerators damage the entirety of the well-justified arguments in favour of certain forms of Energy from Waste, e.g. anaerobic digestion (AD). It is a travesty that support for AD is being jeopardised by association with incineration.

7.38. As with other types of waste facility, a barrier to delivery is the lack of meaningful engagement with communities at an early stage.

7.39. Incineration is currently used as the standard reference project in Outline Business Cases for waste PFIs. AD should be used in place of incineration as part of the reference project for all PFI procurement, alongside ambitious waste reduction and recycling targets.

7.40. Further barriers in respect of AD plants arise from reluctance on the part of local authorities to ensure the segregation of food waste and to conclude the appropriate agreements with AD contractors. Anaerobic Digestion ideally requires a feedstock of waste food that has been source segregated. The locating of AD plants in rural areas, where they can also take agricultural waste, presents little problem.

7.41. Local authorities often pursue the wrong sort of Energy from Waste, focussing on increasing incineration capacity rather than AD capacity.

7.42. AD is a highly efficient technology for recovering energy from bioplastics as well as sewage, farm and food wastes, and variants to process green wastes are under development. AD is a clean technology and AD plants, well maintained, are free of emissions, toxic or otherwise, in contrast to incineration plants where the products of combustion are released into the local environment (to air and land).

7.43. Moreover, as regards exploitation of the recovered energy, AD is flexible; the recovered gas can, if fed to the grid, be used efficiently for both heating and power generation purposes. Alternatively, electricity can be generated adjacent to an AD plant.

7.44. The digestate from the AD process is an excellent soil improver. If the feedstock has derived from source separated (food or green waste) origins, the fertiliser can meet PAS 110 standards for fertiliser, replacing chemical fertilisers and improving soil quality.

7.45. AD is an expedited natural biological process, which is often ‘talked down’ by incinerator operators in order to support their incineration agenda. AD is often confused in the public mind with incineration, thus undermining potential public support. "The public perception of energy from waste [is] often closely associated with

incinerators..."[34] This association between EfW and incineration is clearly counter-productive for the promotion of AD.

7.46. Anaerobic Digestion ideally requires a feedstock of waste food that has been source segregated. The locating of AD plants in rural areas, where they can also take agricultural waste, presents little problem. UKWIN believes that energy recovered via AD should be widely seen as, and promoted as, playing a definitive part in the UK strategy for energy in the future.

7.47. Regarding the positive contribution that AD could make to meeting energy requirements and in view of the National (Gas) Grid's proposal for biogas to replace North Sea gas in the domestic mains, UKWIN calls upon the Government to heed the National Grid's warning against Local Authorities entering into "long term contracts with companies to incinerate the waste, meaning that the opportunity to convert to renewable gas and gain the associated benefits is missed".

7.48. The National Grid estimates half the country's household gas heating could come from biogas made from waste, so providing a reliable source of energy as North Sea reserves run down.

7.49. The National Grid looked at the use of biodegradable waste streams including sewage, food and wood to make biogas for injection into the national gas pipelines. This is already widespread in Europe (Germany, France, and Austria) and parts of the US. The report summarises a major study for the NGC by analysts Ernst & Young and calculated that biogas could offer 18% of the UK's total gas consumption, 48% total domestic gas demand and 10% of the overall UK energy demand. Such a scenario would require £30 billion of capital expenditure, the report suggests, but adds that £20 billion investment is needed anyway in the UK's waste management infrastructure.

7.50. A small quantity of energy-rich biogas is already being made around the country in a growing network of anaerobic digestion facilities. Biogas is also being produced from many of the nation's landfill sites. United Utilities, the UK's largest listed water company, recently announced plans to sell surplus sewage gas to the National Grid.

7.51. However, at the moment almost all biogas from AD and sewage is burned to generate electricity at efficiency levels of around 30%. If the gas was to be injected into the gas grid and delivered straight into consumers' homes, it would be utilised for heating at efficiency rates in excess of 90%.

[34] Defra Waste Strategy Board, Minutes from Meeting of 21 January 2010, available from: http://www.defra.gov.uk/environment/waste/strategy/documents/wsb-100121.pdf

7.52. The "valuable resource" of biomethane just requires removal of contaminants using established technology. The main hurdle, says NGC, is getting the right incentives in place to drive biogas injection, rather than electricity generation which is driven by current ‘renewables’ subsidies. Use of gas through the grid would more than double the contribution of existing renewable gas sources to the renewables target, and we understand that negotiations are in progress with Defra to set a rational structure for heat and power subsidies.

7.53. **What role should Government, industry and voluntary groups play in communicating the benefits of EfW to local communities?**

7.54. All of these should cooperate to distinguish between AD and incineration, to communicate the benefits of AD.

7.55. **How can Government best support local government in the development of waste management plans that include EfW facilities?**

7.56. The Government should not attempt to support local government or others in developing plans that feature waste incineration (including gasification, etc.) with or without energy recovery.

7.57. **What steps can be taken to encourage community ownership of EfW facilities?**

7.58. Community cooperative ownership of AD plants should be funded as a part of the community infrastructure where this is justified. Greater engagement with communities regarding the location, size and type of facilities required would contribute to a greater sense of community ownership of the resultant facilities. There is potential in rural areas for farmers to work together with others in the local community.

8. **Disposal** (Call for Evidence 2.8)

8.1. Before responding to the Government's question there are several points to be made about waste disposal in general, and landfill in particular.

8.2. Landfilling is better than incineration for plastics, although the reduction, reuse and recycling of plastics are preferable.

8.3. The Government acknowledges, for example in the 2007 Waste Strategy, that "burning plastics has a general net, adverse greenhouse gas impact due to the release of fossil carbon" and that this can "outweigh the returns of energy recovery".

8.4. Recycling, by contrast, shows "significant potential for carbon and energy savings through displacing virgin materials". The academic literature strongly supports these conclusions.[35]

8.5. Landfill does not have the opportunity costs associated with incineration, because while incinerations require constant feedstock, landfills do not.

8.6. Landfill sites also offer the potential of landfill mining in the future, so plastics that are not currently recycled can be stored in the ground and recycled at a later date when this becomes more technologically feasible and economically attractive.

8.7. The UK should classify incineration as a form of disposal, rather than recovery, within the waste hierarchy, unless operators can prove that based on a feedstock of non-recyclable and non-compostable residual material, the facility would be deemed efficient in accordance with the Revised Waste Framework Directive, and further demonstrate that such feedstock would be available for the lifetime of the facility without violating the proximity principle.

8.8. Where incineration is technically classed as a form of recovery, it should be treated as the lowest form of recovery, especially in instances where heat is not fully harnessed.

8.9. Incineration does not equate to zero waste to landfill, as at least some if not all bottom ash and Air Pollution Control residues are landfilled, sometimes in the form of hazardous landfill. Provision for hazardous landfilling is inadequate to handle sustained deliveries of hazardous / eco-toxic incinerator ash.

8.10. Talk of a general landfill crisis is baseless. Any lack of permitted capacity is probably because landfill sites are being mothballed

[35] For example: Ola Eriksson and Goran Finnveden *Plastic waste as a fuel - CO2-neutral or not?*, Energy & Environmental Science, 2009, 2, 907–914.

due to lack of demand. Estimates of the number of years of landfill remaining are distorted by incorrect landfill density assumptions and incorrect assumptions regarding quantities of waste that will be sent to landfill.

8.11. To support better strategic planning, UKWIN advocates for the use of a higher landfill density assumptions. These should be based on local studies demonstrating actual in-situ densities, and in lieu of such local studies, a minimum in-situ density of 1.1 – 1.34 per cubic metre should be used, in accordance with the Staffordshire And Stoke-On-Trent Waste Local Plan Inspector's Report on Objections[36] (that following a detailed and extensive survey of densities in practice concluded there was "no justification to adopt the lower figure proposed by the operator" of 0.85 tonnes/m3).

8.12. This Inspector's report also shows that landfill capacity calculations do not need to be limited to sites with environmental permits - there is a difference between permitted capacity and potential landfill capacity.

8.13. UKWIN calls attention to PPS10 Companion Guide: "4.13 In making forecasts, account should be taken where possible of the impacts of commercial and legislative drivers of waste production, recognising that these are not certain. Such measures include the landfill tax, the Aggregates Levy, the Waste Electrical and Electronic Equipment Directive and the introduction of the Hazardous Waste Regulations in July 2005".

8.14. **How best to further reduce the amount of waste going to landfill?**

8.15. By maximising reduction, reuse, recycling and AD, and by not incinerating discarded material, thereby avoiding incinerator ash to landfill.

8.16. By maintaining the landfill tax escalator.

8.17. By eliminating non-recyclable products and materials.

8.18. **What are the types of waste where a continuation of landfill might be acceptable?**

8.19. Plastics that are not currently recycled (leaving scope for future landfill mining and subsequent recycling); bio-stabilised waste resulting from MBT and AD processes; inert, non recyclable C&D materials.

[36] See: http://www.staffordshire.gov.uk/NR/rdonlyres/2505E0BB-E96F-4EE1-A6B5-81F072CBCC5E/21623/remainingapr02.pdf

8.20. Methane capture could contribute to making a wider range of wastes to landfill less harmful to the environment, although UKWIN is aware of some deficiencies with current methane capture technologies.

9. Additional Evidence

9.1. There are several terms frequently used in the waste management discourse that are open to multiple interpretations. UKWIN wishes to use this Additional Evidence section to explore some of these terms, and make some further points.

9.2. The first contested term is “zero waste”. Simply put, whilst some are content with a simplistic interpretation involving the slogan “zero waste to landfill”, UKWIN strongly believes that such one-dimensional interpretations fails to reflect the genius of zero waste, and that there is no place for incineration in a zero waste economy.

9.3. Zero waste implies the goal of total waste prevention. It assumes that reuse and recycling can account for 90% or more of “surplus resources”, all (or nearly all) of which are salvageable. Zero waste assumes that material passes around a loop: manufacture → sell → use → become surplus → reuse / recycle / remanufacture. Zero waste assumes that biological materials should be allowed to follow the natural life cycle processes.

9.4. The “zero waste” concept does not imply that people and businesses will cease to have material for which they have no further use. What it does imply, by definition - for manufactured products - is a scenario of total recycling and reuse, and - for food and garden waste - a state of total recycling that, in part, may include energy recovery via AD. For this scenario to be realised, consumers, domestic and commercial, have to view what might seem today to be “waste” to them, as someone else’s valuable resource.

9.5. Another contested term is “residual waste”. Whilst in theory residual waste is material that cannot be reused, recycled or composted, there are many instances where perfectly reusable, recyclable or compostable material is managed as if it were “residual waste” and burned in waste incinerators.

9.6. Confusion inevitably arises in relation to waste contracts, and planning and environmental permit applications for waste incinerators, that use of the term “residual waste” to mean waste left over after some removal of some recyclable and some compostable material, instead of meaning only that waste that cannot be reused, recycled or composted.

9.7. If residual waste is the excess that remains after all materials that can be reused are reused, and all materials that can be recycled are recycled, and all material that can be composted has been composted, then a zero waste economy should plan for a future with very little residual waste indeed. In such a zero waste future our members could expect to witness the fulfilment of our shared vision of a United Kingdom without incineration.

9.8. Another contested term is “sustainable waste management”. UKWIN strongly asserts that waste incineration cannot ever be appropriately described as contributing to sustainable waste management. Only the highest rungs of the waste hierarchy can be considered “sustainable”, i.e. reduction, reuse, recycling, composting and AD. Where alternatives solutions exist, the most sustainable will be the one with the lowest life cycle carbon footprint.

9.9. Incineration is not sustainable by virtue of its feedstock composition and its emissions. Any disposal or EfW process that consumes unsustainable (non-renewable) material, such as fossil derived plastics, cannot itself be accurately described as a sustainable process.

9.10. Our members also note that the term “combined heat and power” or “CHP” appears to be in frequent use, even when precious little heat is harnessed and put to any meaningful use. An obvious example of this is the South East London Combined Heat and Power (SELCHP) incinerator.

9.11. The phrase “Energy from Waste”, and its acronym EfW, are frequently applied to the recovery of energy from mixed or “residual waste” via incineration and / or gasification although it may be applied to AD. In the case of AD, which uses a natural recycling process, the feedstock should not be described as waste – which it is not - but rather as “recyclable biogenic material”, and AD should sit above Recovery within the waste hierarchy. The EfW concept is inconsistent with zero waste since in a zero waste economy there would be no waste to incinerate or gasify.

9.12. The power output from waste incineration and gasification plants is often described as ‘renewable’. Much, if not all of it is not. In all cases the percentage of energy in the feedstock that actually emerges as power is small – generally no more than 20% and often less. Partly as a consequence, the CO2 emissions for every unit of power produced are much greater than for a modern fossil power station; so much greater that even if one half of the feedstock does come from renewable sources (and can therefore, arguably, be discounted), the CO2 from the non-renewable element still massively exceeds that from the fossil fuel based power station.

9.13. Whereas, the methane produced via AD can be used for heating purposes and if it is burned in modern appliances, a very high proportion of the energy (c 90%) is gainfully used[37].

[37] If the gas is used to fuel a gas engine driving a generator only some 30 – 35% of the energy will be gainfully used unless the engine coolant can itself provide a useful heat source. Used to fuel a modern gas fired power station 50%+ efficiency is achievable.

Appendix A – A Bridge Half Built

UK National Waste Policy – A Bridge Half Built

A Zero Waste Alliance Declaration

October, 2006

Zero Waste Alliance UK is a company registered by guarantee in England & Wales, company number 4452297, www.zwallianceuk.org

UK National Waste Policy - A Bridge Half Built

In July 2002 the Zero Waste Charter was launched at the House of Commons, and has since received wide national and international backing. It argued that there was a growing environmental imperative for the reduction, recycling and composting of waste to reduce:

- the dangers to human health of incinerators and landfills,
- CO2 emissions,
- the pressure on virgin forests, on minerals and on rapidly degrading soils.

The 10 point charter set out a strategy for moving to Zero Waste in the UK, notably by:

- maximising the recycling of dustbin and of bulky waste,
- introducing the doorstep collection of organic waste and a composting infrastructure
- banning the thermal treatment of mixed waste and the landfilling of untreated biological waste
- limiting waste disposal authorities to 10 year contracts to ensure flexible facilities to complement the growth of recycling and composting
- introducing a disposal tax and earmarking its proceeds to promote Zero Waste.
- accelerating and extending producer responsibility legislation

After the launch of the Charter, the Government's Strategy Unit supported many of the principles of the Charter. It led to a radical increase in the landfill tax. It supported increased rates of recycling and composting, secured additional funding for WRAP to engage in waste prevention and recycling, and for the first time recommended Mechanical and Biological Treatment as an alternative to incineration and landfill as a means of handling residual waste.

But it left a bridge half built. And policy has in the meantime slipped back to its previous groove: timid on targets, and a promoter of incineration.

Climate change will not be countered by limited ambition. Leading countries and regions in Europe are now recycling and composting 60% of their municipal waste. The UK remains a straggler. Recycling has doubled in four years, but still stands at no more than 23.5% in 2004/5. DEFRA's current review proposes a maximum target of 50% by 2020, a level that the best UK

authority is already meeting. This sets the bar too low. It offers too little too late.

Holding back recycling and composting and promoting incineration will not reduce CO2 emissions. Yet this has been the consistent thread of Government policy since the Strategy Unit Review:

- The UK government is notorious in Europe for its opposition to the EU Bio waste directive, and has had it shelved

- The UK Animal By-Products Regulations have set levels of treatment way beyond those operating in the rest of the EU, raising the cost and discouraging the composting of domestic and commercial food waste

- The Government is pressing the EU Commission to redefine incineration as recovery rather than disposal

- Funds for PFI waste disposal contracts have been increased, encouraging large scale, capital intensive disposal technologies and 20-25 year contracts and reducing the incentive to maximise recycling[1]

- In proposing long term national targets for incineration, but only modest short term recycling and composting targets for individual local authorities (a maximum of 30% for 2007/8) Government encourages disposal authorities to crowd out recycling and composting by the construction of large scale incinerators.

- The escalating landfill tax coupled with LATS, without graduated taxes on other forms of disposal, encourages a switch from landfill to other disposal options rather than the maximisation of recycling and composting.

- DEFRA has substituted a tick box sustainability appraisal for the Best Practical Environmental Option, which has facilitated proposals for incineration at public enquiries

- In spite of massive local opposition the DTI has approved the proposal for a giant incinerator at Belvedere in East London (up to 800,000 tonnes, making it the largest incinerator in Europe), so creating a long term appetite for paper and plastic from Greater London, that should be recycled to save CO2 emissions. Belvedere's approval sets a precedent for giant schemes throughout the country.

DEFRA's current Review is strong on the rhetoric of recycling, but it fails to will the means. It remains a charter for incineration not for Zero Waste. It argues for incineration as a means of countering climate change on two

[1] The National Audit Office report notes that PFI deals take longer to bring to financial close than other types of procurement, and that after nine years, only six residual waste plants are in place or under construction.

grounds: that it replaces methane producing landfill, and that it substitutes carbon neutral electricity production for fossil fuel power stations. [2]

But it under-estimates:

- The loss of stored up energy embodied in recyclable materials prematurely incinerated (notably paper, aluminium, organic waste and plastic).

And it takes no account of:

- the capture of methane from landfill, which at the high rates assumed elsewhere by DEFRA makes landfill broadly comparable in terms of net CO2 emissions to electricity-only incineration.[3]

- the fact that electricity-only incinerators generate[4] more fossil CO2 than gas fired power stations and more in total than coal power stations, while CHP or heat only incinerators are only marginally better than gas fired stations even if the heat is put to good use - not always possible even in areas like Scandinavia where the demand for heat is higher than in the UK[5]

- the sequestration of carbon in depleting soils through the application of compost, or stabilised residues from MBT plants.

- the lifecycle energy costs involved (and the waste generated) in the production of the incinerators themselves

Incinerators are producers of brown energy not green. They do not reduce green house gas emissions but increase them, both because of the overall CO2 emissions at their strikingly low current levels of efficiency of 25% or less, and because their destruction of the 'grey energy' embodied in the materials they burn increases the need for new energy intensive virgin materials.

The incentive structure and the process of decisions on disposal of waste are tilted towards incineration. Whereas stabilised residues from MBT that are

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[2] Defra (2006) Review of England's Waste Strategy: A Consultation Document, February 2006. Its wording is: "EfW reduces emissions of greenhouse gases in two ways: because the wastes could otherwise go to landfill and generate methane; and because emissions from the biomass fraction of the waste, which are carbon-neutral, are likely to replace those from fossil generation." p.60

[3] Eunomia, A Changing Climate for Energy from Waste, Friends of the Earth, May 2006.

[4] Eunomia, op. cit. By 2020 forecast advances in power station technology and the growing proportion of plastic in residual waste means that energy only incinerators will emit twice the fossil CO2 of gas power stations, and probably more than new or refitted coal power stations using up to 20% biomass. Wastes contain both fossil carbon derived from oil and other fossil fuels and biogenic carbon from wood and plants. When biogenic carbon and time are included in the analysis, energy from waste incineration – where only electricity is generated – looks like a mediocre performer (Eunomia 5.2). Indeed, if the residual waste is landfilled after the stabilising treatment now required, it is only marginally better than landfilling. The Eunomia report contains a valuable critique of the ERM Report for DEFRA that has been used to justify the Government's incinerator policy, see pp.74 sq. and ERM (2006) Impact from Energy from Waste and Recycling Policy on UK Greenhouse Emissions, Final Report for Defra, January 2006

5. Eunomia, p6

landfilled are subject to the full landfill tax, bottom ash from incinerators is classed as inert, and charged only £2 a tonne.

Far from facing a graduated tax as a means of disposal, incinerators receive more Government funding, and have greater access to private finance, than recycling or composting. Accordingly they remain the technologies of choice for disposal authorities which the Government have left with the decisive institutional power in municipal waste management.[6]

Even where, because of public opposition, disposal authorities have fought shy of incineration or its modern variants pyrolysis and gasification, they have continued to negotiate 20-25 year inflexible contracts, incorporating Mechanical and Biological Treatment (MBT) plants, that produce 'refuse-derived fuel' as a feedstock. They have made MBT, a potentially more flexible means of stabilising residual organic waste and suitable for the transition to Zero Waste, into a processing arm for incineration, and a barrier rather than a support to Zero Waste strategies.

Zero Waste Alliance Proposals

Zero Waste policies have had to swim against the institutional and policy tide, rather than being carried along by it. The Zero Waste Alliance therefore urges the Government and local authorities to re-orient their policies in the direction of Zero Waste, in line with leading regional and national governments overseas, and further to the 10 points of the original charter, adopt the following specific measures:

1. **Set long term recycling and composting targets of 75% for all local authorities by 2015, (and a minimum of 60% for each individual local authority) along with waste minimisation targets, to prevent their crowding out by local and regional long term disposal contracts.**

2. **Press the EU to introduce the Biowaste Directive, and its requirement for kerbside kitchen waste collections in all cities, towns and villages with over 1,500 population.**

3. **Switch the government subsidy of PFI schemes to the start up costs of food waste collection and composting, as part of the Treasury's forthcoming Comprehensive Spending Review.**

4. **Extend the grant of carbon credits to recycling and composting to reflect their impact on the reduction of CO2 emissions generated by the production of virgin materials.**

5. **Extend Producer Responsibility Legislation to cover all materials in the household waste stream, and raise the targets for recycling**

[6] DEFRA's lack of clarity on MBT residues and composting requirements is a further discouragement to disposal authorities seeking an alternative to incineration.

of plastic packaging, glass and metals under existing legislation to those set by the leading countries in Europe.

6. **Recognise incineration as disposal not recovery, in line with the EU Waste Framework Directive and rulings of the European Court of Justice.**

7. **Fund a major research programme to identify the hazards of nano particles, particulate aerosols, and brominated flame retardants that arise from the burning of mixed waste.**

8. **Introduce an incineration tax of at least £12 per tonne.**

9. **Charge incinerator bottom ash at the full level of landfill tax (rather than the £2 a tonne which it currently enjoys by virtue of its unwarranted classification as inert waste) and reduce the landfill tax to £6 a tonne for bio-degradable waste, stabilised to the levels set out in the 2nd draft of the Biowaste Directive.**

10. **Require compulsory insurance against future pollution and health claims for all disposal and recovery facilities.**

The past four years have not been wasted. The ground for a radical increase in recycling and composting is now prepared. St Edmundsbury has become the first council to pass the 50% recycling and composting target. The leading continental and North American authorities are now reaching 75%. They mark the path to Zero Waste.

The imperative of climate change has, too, at last been unequivocally recognised by scientists, by the media and now by all major political parties. But it is not reflected in waste policy. In spite of the evidence that recycling and composting lead to major CO2 savings relative to incineration and landfill - WRAP estimates the savings of current levels of recycling and composting at 10-15 million tonnes of carbon equivalent per year[7] and in spite of its higher CO_2 emissions relative to gas fired electricity generation, the Government is still promoting incineration as a source of green energy.

What is required is return to the boldness of the Strategy Unit's policy, and a shift of finance and incentives towards composting and recycling. Climate Change policy calls for it. The Government should respect the evidence, free itself from the disposal centred waste industry, and complete the work that was left half finished after the Strategy Unit's Review.

The Zero Waste Alliance

October 2006

[7]WRAP, Environmental Benefits of Recycling. An international review of life cycle comparisons for key materials in the UK recycling sector, May 2006. The study was based on a comparative review of 55 international life cycle studies, assessing 200 scenarios.

Appendix B – A Critique of WRATE

Failures of WRATE modelling in the Wales Waste Strategy

WAG has been relying on WRATE for the Welsh Regional Waste Plans and for the 2009 review of the Wales Waste Strategy. Yet it's badly flawed.

In the 'WRATE' assessment ([1] ***W****aste and* ***R****esources* ***A****ssessment* ***T****ool for the* ***E****nvironment*) for the Welsh Waste Strategy (WWS), the results show incineration very positively. Incinerator companies (eg. Viridor in Cardiff) claim their plants have negative carbon footprints. Such results are at odds with much of the peer reviewed literature; with the Waste Strategy 2007 for England [2] and even with the previous modelling by the UK Environment Agency for WAG [3] .

It has been long been clear that a lot of energy can be saved by recycling. For more than a decade it's been established that this energy saving is very much greater than energy recoverable by incineration [4,5]. The earlier modelling clearly demonstrated that recycling gives net reductions of climate change emissions, while incineration is a net generator of climate change gases.

WRAP's specialist review of international studies "*Environmental Benefits of Recycling*" [6] shows how increased recycling is helping to tackle climate change and emphasises the importance of recycling over incineration and landfill as the appropriate way forward. The evidence from WRAP said:

- *In the vast majority of cases, the recycling of materials has greater environmental benefits than incineration or landfill.*

WRAP concluded (s.14): *The message of this 2006 study is unequivocal. Recycling is good for the environment, saves energy, reduces raw material extraction and combats climate change.*

The WWS study found on the contrary:

> *The results of the WRATE assessment suggest that Energy Recovery from paper and card via a CHP Incinerator has a greater environmental benefit. These results are influenced by the way WRATE calculates the global warming potential, differentiating between biogenic and fossil fuel carbon emissions. This point is discussed further in the results. This setting cannot be varied in the WRATE model."*

This is an anomalous result inconsistent with WS2007 and the majority of the published literature, which brings the credibility of WRATE into question.

The Industry shares criticisms of WRATE

Dirk Hazell, chief executive of the Environmental Services Association (ESA), explained to the London Remade conference (5 Oct 2009 [7]) ESA is working to develop a metric to measure the carbon footprint of waste management activities. He said the waste sector felt that WRATE - which is already used by local authorities to procure new waste contracts and take into account emissions - is "inappropriate" for some decision-making because some of the default settings were too generic.

Daniel Silverstone, chief executive of London Remade, highlighted the limitations of the government's present approach of CO2 from waste: "While the global impacts of waste management account for 3% of carbon emissions globally and in the UK 4% of GHG emissions are traced to methane emissions, none of this takes into account the carbon impact of logistics, supply chain, manufacturing process and the global trading of recyclables."

Bias to Incineration
The Low Carbon Transition Plan in respect of waste [8,9] takes no account of CO2-savings from recycling or emissions from incineration, considering only biogas from anaerobic digestion and (reduction of) landfill. The expected 'saving' is only 1 Mt of carbon equivalent, yet the envisaged combustion of wood waste and domestic waste generating electricity at high CO2 per kWh would release ten times that (but disregard it as industrial emissions).

WAG's WRATE [1] makes unrealistic assumptions that bias results on climate impact towards incineration over recycling
all incineration is high thermal efficiency CHP and
the carbon intensity of future displaced electricity is the same as today's.
ignores the extra recyclates and their higher quality recovered from MBT of residual waste

Eunomia analysis [10] finds that one of the best performing systems is an MBT AD system – largely as a result of the benefits attributed to recycling materials that are recovered during the treatment process.

WRATE excludes emissions of carbon or biogenic origin, a fault that sets it at odds with the IPCC, which says [11]:
If incineration of waste is used for energy purposes, both fossil and biogenic CO_2 emissions should be estimated.
WRATE's approach thus fails to cover the benefits of delaying emissions of CO2 (eg. using wood as building material or burying in landfill) or sequestering carbon in PVC and mixed plastics in landfill rather than combusting with release of chlorine compounds and metal toxins.

Assumptions on carbon intensity of displaced electricity:
Electricity from incineration does offset carbon emissions from substituted generation, but the future electricity mix has to be modelled. Current policy requires a progressive reduction in the carbon intensity of the future fuel mix, which substantially reduces the benefits as future electricity comes with much lower carbon emissions. Although a "sensitivity" test was carried out using what is claimed to be a '2020' energy mix in WAG's WRATE report, this is not based on the reductions in carbon intensity included in current policy as detailed in the *UK Low Carbon Transition Plan* [9].

Moreover, a 2030 mix is more typical for an incinerator contracted for 25-30 years from 2015.
The UK plan shows approximately 75% reduction in carbon intensity (from over 300 to ~80 g CO_2/kWh) is anticipated between 2020 and 2030. To contribute positively on climate change post-2030, any incinerator should produce electricity with a carbon intensity under 80 gCO_2/kWh. However the carbon intensity of incineration, even if biogenic carbon is ignored, is more than 300 g/kWh. Thus incineration becomes unarguably, in the words of the Environment Agency [12] a "carbon sinner" rather than a "carbon sink".

Assumptions on carbon in future waste
Indeed, future incineration would be still worse, as the biogenic proportion of residual waste reduces with increased recycling. Whilst unsorted waste is calculated to derive

66% of the calorific value from biomass this falls to 38% when recycling ~45% and then to just 30% biomass when recycling ~60%. This is because the wastes that tend to be pulled out for recycling/composting are those like paper and kitchen waste with high biogenic proportions. This concentrates the plastics and composite materials in the residual waste (and burning is not the Best Practicable Environmental Option [13] for plastics wastes). Thus the carbon intensity of incineration, if biogenic carbon is ignored, would rise to more than 600 g/kWh in 2030.

Bias against biostabilisation and good landfill management
WRATE underplays the extent to which stabilisation-type treatments decrease the environmental impact of material that is landfilled after being stabilised. It hardly allows for the reduction in respirability of treated residues (despite the high values 80-90% found in practice). It largely ignores the biological changes undertaken in the processes - it attributes them with high methane emissions and thus climate change impacts. This has an impact on not only the GWP indicator, but also the Eutrophication indicator (relating to nitrogenous emissions, principally ammonia from landfill). The consequence is that any system that is assessed using WRATE and which includes a residual landfill or MBT/compost element will almost invariably appear to perform worse than a mix including higher levels of incineration. Almost uniquely amongst modern LCA models, WRATE penalises MBT and compost-based options.

WRATE fixes the capture rate of landfill gas at 75% (change promised in a future issue of the software) so makes no allowance for good management, in gas capture and in capping with an oxidising layer (as appropriate for landfilling 90% stabilised biowaste).

When the flawed methodology for stabilised biowaste was raised at the WRATE Users conference (18 Nov. 2009 in Birmingham) the EA's Terry Coleman said he had previously been unaware of the flaw in their methodology. Yet it had been raised by Eunomia consulting and by New Earth Solutions who conducted the EA-validated biostabilisation trials.

Inconsistent with the EA's guidance on generating power from Biomass
The Environment Agency's *Biomass: Carbon Sink or Carbon Sinner* [12] points out the need to take into account emissions from transport, nitrogen fertilizer production, land use changes and conversion efficiency, because these could increase the biomass total to as much or more than the emissions from gas-fired power. For example, short-rotation coppice woodchips for electricity would emit 35-85% fossil GHGs compared with gas CCTG per kWh. Yet WRATE assumes zero fossil GHGs in biomass. The fossil GHGs released in producing and supplying the food that we waste should similarly be included in assessments that claim GHG savings from energy recovered from that waste.

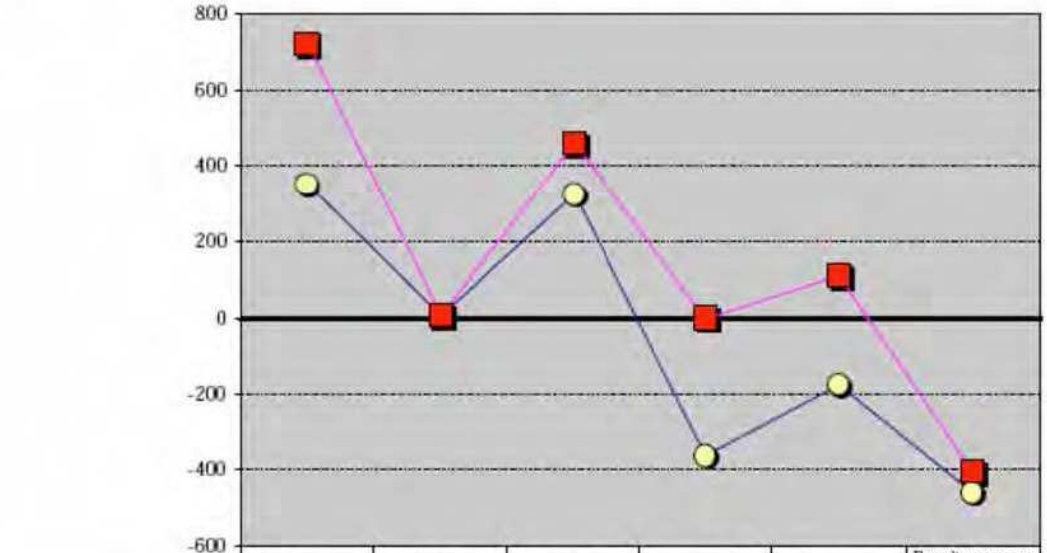
WRATE does not properly assess carbon emissions from incinerating waste wood, taking it to combust with zero CO2. Its "bio-CO2" of course goes immediately into the atmosphere, whereas alternative use on land has slow release, some delayed for decades or recycled into biology, while alternative burying in landfill sequesters the lignin-carbon (~30%) indefinitely. Proper LCAs include the wood-carbon sequestered long-term in landfill or spread on land as char. The EA has developed its Biomass Environmental Assessment Tool [14] that addresses WRATE's deficit in GHG accounting, but only for the segregated biowaste streams.

Climate Change scientists internationally have called this a “critical climate accounting error” [15] and propose fixing it by tracing the actual flows of carbon from smokestacks, whether fossil of bioenergy. Biomass should receive credit to the extent that it adds carbon from enhanced plant growth or uses residues or biowastes. Alternative use of biowastes on land that builds soil carbon or serves as compost has likewise to be credited.

Failure in comparison with validated life-cycle analysis
WRATE does not give robust results in comparison with internationally adopted life-cycle analysis. It may work for relative comparisons of incineration options, but fails for comparison with non-thermal alternatives as shown eg. by the very different outcomes of using the ATROPOS model for Ireland’s waste management options (Greenstar [16]). With a similar dispersed settlement pattern and urban-rural mix to Wales, this found that “*scenarios using incineration were amongst the poorest performing*” while those using MBT were much better.

The detailed review by AEAT [17] for the European Commission similarly found that MBT when sequestration is taken into account performs much better than energy from waste. The graph shows their findings when landfill gas is allowed for and incineration is competing with wind power (or other renewables) as applies when incineration competes for subsidy with renewables, as in the UK. The lower line applies when Carbon sequestration is included (which WRATE fails to do), when MBT to landfill (Col.4) comes out much better than incineration (Col 2) including MBT output to incinerators (Col.5) and almost as good as recycling/composting (Col.6). WRATE takes the landfill comparator as Col.1 (raw waste) which the Landfill Directive excludes.

Figure 21: Overall net greenhouse gas fluxes from waste management options – EU-average landfill gas collection and wind electricity replaced kg CO2 eq/tonne MSW.



	Landfill raw waste	Mass burn	RDF-FBC	MBT landfill	MBT incin	Recycling, compost & AD
Net flux	350	8	324	-303	-178	-458
Net flux excluding sequestration	720	8	458	1	111	-403

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Greenhouse Gas Balances of Waste Management Scenarios

Report for the Greater London Authority

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Executive Summary

Measuring greenhouse gas (GHG) emissions from waste management is an extremely complex subject area. Written in appreciation of the time constraints of the readership, it is therefore intended that this Executive Summary can also function as a standalone summary report. It is thus somewhat more comprehensive than might normally be expected.

The essential goal of this study was to measure and rank a range of scenarios for the management of residual waste[1] with regard to their performance on GHG emissions. Only emissions of carbon dioxide (CO_2) and methane (CH_4) are included within the scope of this study. Where reported in this document, these are expressed in CO_2 equivalents, whereby methane is assumed to have 23 times the potency of CO_2 as a GHG.

It should be noted that we do not at any point in the study aim to assess:

- Whether some of the more complex scenarios will perform effectively in practice;
- Costs or gate fees associated with any of the scenarios; and
- Alternative environmental impacts.

A fundamental consideration when conducting this type of analysis is the scope of system modelling, i.e. where does GHG accounting start and finish. 'Whole system' modelling is a term familiar to proponents of lifecycle assessment (LCA) approaches, and although this is often considered the ultimate goal for such studies, it is not fully appropriate here. It is important to note in this context that we have omitted consideration of emissions from *collection* of residual waste. This is both the result of their relative insignificance[2], and the fact that we are assessing scenarios for the treatment of residual waste and thus (other things being equal) emissions from collection will be the same for all scenarios.[3] For each scenario, we have also omitted the energy demand associated with materials required to construct waste treatment facilities, which in many analyses are typically small compared to operational elements.

Methodology

It should first be noted that our methodology for undertaking this study has received formal peer review.[4] Using our Atropos© model, which has been developed internally over several years, we have adopted what might be regarded as a state-of-the-art approach. This largely echoes that undertaken in the recent Stern Review[5], but with some important distinctions. There are three distinctive features to Atropos©, which differentiate it from typical LCA methodologies:

- Monetization, through estimation of marginal damage costs;
- The addition of a 'time-profile' to GHG emissions through discounting;

[1] Residual waste is the fraction of the waste stream which remains following removal of materials for recycling at the kerbside and at 'bring' sites

[2] They typically represent less than 1% of greenhouse gas emissions (as discussed in Section 5.3)

[3] We are, however, aware that different types of facilities are likely to be implemented at different scales, and therefore have modelled transport costs between treatment stages

[4] Holland, M (2007) Peer review of a study by Eunomia for the GLA into the greenhouse gas balances of waste recovery technologies, EMRC on behalf of the Greater London Authority, October 2007

[5] Stern Review: The Economics of Climate Change, HM Treasury, October 2006

- Inclusion of all non-fossil emissions of CO_2; and

The marginal damage costs of GHG emissions are also generally expressed as the social costs of carbon (SCC). The SCC represents the economic cost to society from climate change actually occurring. As demonstrated in the Stern Review, there is a recent convention of projecting increasing marginal social costs of carbon over time. Stern has been criticised, however, for the use of excessive values for the SCC.[6] Thus, following the approach of previous work undertaken by Eunomia,[7] we have used what we consider to be more acceptable, lower values based on the available literature - although it should be acknowledged that this kind of estimation will always be somewhat controversial.

Discounting represents a counter-weight to the rising SCC and enables comparison of costs and benefits that occur at different points in time by converting all costs and benefits to present monetary values. It is based upon the premise that costs and benefits occurring at some future date are worth less to current society i.e. we would rather have benefits now, and defer costs to future generations.

There is considerable debate regarding the choice of discount rate, and the Stern Review has received similar criticism, this time for the low rates employed. For the purposes of the present study we have applied the declining discount rate proposed in the HM Treasury Green Book. Again, we have used this approach previously and feel it is more acceptable, but once more, we are aware of alternative views.

The monetisation and discounting elements within Atropos© facilitate the inclusion of all non-fossil CO_2 in our analysis.[8] Traditional LCA methods exclude all emissions from non-fossil CO_2 on the basis that they are simply balancing the CO_2 which has already been removed from the atmosphere during plant or animal growth. In the GHG balances compiled through LCAs, only methane emissions from landfill are counted within what might be considered a fairly arbitrary 100 year period. The climate, however, responds no differently to fossil or non-fossil CO_2, and thus it is important to include all emissions on a like-for-like basis where comparative analysis is concerned.[9]

It should be emphasised that the argument for consideration of GHG emissions from non-fossil carbon is made within the context of a comparative study of residual waste treatment technologies only. This argument should not be taken out of context and is not intended to refer to any other areas, such as comparison of renewable energy sources with those from fossil fuels or the compilation of a GHG emissions inventory, which is usually undertaken according to IPCC conventions.

In this study, all CO_2 and CH_4 emissions are modelled with no time limit imposed. Waste composition data, the carbon characterisation of each waste material type, and the mineralization profiles of the main carbon fractions (i.e. lignin, cellulose, and hemicellulose fractions of paper, food waste, etc) are all considered in Atropos©. Therefore, the model accounts for slow, medium, and fast degradation of carbon, and the emissions from these fractions (which are discounted over time) within landfill.

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[6] Nordhaus, W (2006) The Stern Review on the Economics of Climate Change, November 2006; Dasgupta, P (2006) Comments on the Stern Review's Economics of Climate Change, November 2006

[7] Eunomia (2007) Managing Biowastes from Households in the UK: Applying Life-cycle Thinking in the Framework of Cost-benefit Analysis: A Final Report for WRAP, May 2007

[8] Non-fossil CO_2 is often referred to as 'biogenic' CO_2 and represents emissions from sources which are not derived from fossil fuels, i.e. which are from biomass, for example, food and green wastes

[9] Albeit taking into account the far greater impact per tonne of methane emissions

Many additional key functions within Atropos© are detailed within Appendix 7, which also provides an example schematic to illustrate the scenario modelling process, as followed by the user.

'Generic' and Technology Specific Assumptions

As stated above, the core objective of the study is to provide a ranking of waste technology scenarios. We are fully aware that there will never be complete consensus upon all the assumptions we have used within Atropos©. Towards establishing this ranking, however, it is necessary to form clear judgements upon a set of fundamental, underlying parameters which underpin our analysis.

We have focused on modelling consistent elements of the lifecycle according to a range of 'generic' assumptions which relate to all technology scenarios. The most important of these relates to the 'carbon intensity'[10] attributed to 'avoided' electricity generation.[11] Other 'generic' assumptions include the emissions reductions offered by materials recycling / reprocessing, the emissions from transportation and the input waste composition for each scenario.

Assumptions relating to specific technologies are also fundamental to this study and underpin the results derived from Atropos©. All assumptions are based not only upon a sound review of existing information, but also upon primary data and personal communications with a range of technology providers. For each technology, we have been careful to undertake our modeling using assumptions which are based upon 'best-of-breed' processes operating today, i.e. technology 'brands' which are proven at commercial - or in the case of some of the novel processes – at demonstration scale.

It was agreed with the Project Steering Group (PSG)[12] at an early stage that the scenarios included for analysis within the scope of this study ought to reflect those most likely to be implemented in London. As a result, a number of alternative configurations have been omitted, as detailed in Appendix 2, and in Section 8.3 with regard to the specific policy context within London.

Results under Central Assumptions

As can be seen from the results presented in Table A under our central approach and assumptions, Atropos© was used to model 24 technology scenarios. Table A reflects marginal SCC (or net externalities), thus taking into consideration the emissions from different technology elements within each scenario, along with the emissions avoided from both energy generation and materials recovery/reprocessing. The results reflect the cost of carbon (equivalents) to society and are based upon treating one tonne of input waste.

[10] The term 'carbon intensity' refers to the level of CO_2 emitted by an energy source, i.e. those which emit high levels of CO_2 per unit output, are considered 'carbon intense'

[11] 'Avoided' electricity generation refers to electricity from other sources for which there is no longer demand due to generation at waste management facilities

[12] The Project Steering Group consisted of members from the Greater London Authority, London Development Agency, and the London Climate Change Agency

Table A: Ranking of Scenarios under Central Assumptions

Rank	Scenario Number	Scenario Description	Net Externality (£s)
1	11	MBT (AD and maturation) with output to landfill and export of biogas for conversion to H_2 for use in vehicles	4.48
2	21	Plasma gasification (following autoclaving) with export of syngas for conversion to H_2 for use in vehicles and plastics to reprocessing	4.83
3	13	MBT (AD and maturation) with output to landfill and export of biogas to H_2 fuel cell for stationery power generation (CHP)	5.25
4	12	MBT (AD and maturation) with output to landfill and export of biogas to H_2 fuel cell for stationery power generation (electricity only)	5.45
5	5	Gasification (following autoclaving) with export of syngas for conversion to H_2 for use in vehicles and plastics to reprocessing	5.75
6	9	MBT (AD with maturation) with CHP, output sent to landfill and plastics to reprocessing	6.01
7	14	MBT (AD with maturation) with output to landfill and compression of biogas for use in vehicles	6.21
8	10	MBT (AD with maturation) with CHP, output to landfill and plastics sent for pyrolysis to synthetic diesel	6.47
9	20	Plasma gasification (following autoclaving) with export of syngas to H_2 fuel cell for power generation (CHP) and plastics to reprocessing	6.50
10	6	Gasification (following autoclaving) export of syngas to H_2 fuel cell for stationery power generation (CHP) and plastics to reprocessing	6.90
11	15(b)	Gasification (following autoclaving) using a gas engine (CHP) and plastics sent for reprocessing	7.35
12	16b)	Gasification (following autoclaving) using a gas engine (CHP) and plastics sent for pyrolysis to synthetic diesel	7.53
13	17	'Biomass' boiler (following autoclaving) using a steam turbine (CHP) and plastics sent for reprocessing	7.67
14	19	Plasma gasification (following autoclaving) using a gas engine (CHP) and plastics sent for reprocessing	7.98
15	15(a)	Gasification (following autoclaving) using a steam turbine (CHP) and plastics sent for reprocessing	8.38
16	16(a)	Gasification (following autoclaving) using a steam turbine (CHP) and plastics sent for pyrolysis to synthetic diesel	8.57
17	8(b)	Gasification (following MBT biodrying and maturation of rejects) using a gas engine (CHP)	9.01
18	7	MBT (biostabilisation) with output sent to landfill	9.55
19	3	Incineration (with CHP)	10.21
20	8(a)	Gasification (following MBT biodrying and maturation of rejects) using a steam turbine (CHP)	10.71
21	18	Incineration (following MBT biodrying and maturation of rejects) using a steam turbine (electricity only)	10.97
22	2	Incineration (with electricity only)	11.45
23	4	Incineration (with heat only)	11.66
24	1	Landfill (with electricity only)	31.90

As can be seen from Table A, the best performing scenarios are those either based upon MBT (AD with maturation) or upon gasification (or plasma gasification), coupled with hydrogen (H_2) fuel cell technologies. This is the result of the far greater conversion efficiencies of fuel cells when compared to other energy generation technologies. Consequently, a greater amount of alternative energy generation is avoided, which delivers significant GHG reductions. The use of H_2 fuel cell vehicles delivers the best

performance due to the avoidance of burning diesel, rather than the avoidance of electricity generation, as is the case with stationery fuel cells.

It should be acknowledged that there has been limited investment and research into the use of waste-derived syngas in hydrogen applications. In addition to the inclusion of an autoclave, a gasifier and a fuel cell within such scenarios, the syngas generated by a gasification facility treating municipal solid waste (MSW) would require processing with a number of intermediate technologies.[13] Today, this would represent a technical risk that is likely to be beyond that which might attract commercial finance. This suggests that our results for Scenarios 5, 6, 20 and 21 should be treated with caution. One of the key goals of this analysis, however, is to report upon 'leading edge' configurations which have the potential to deliver both GHG benefits and which fit with wider policy goals at national and city level. The PSG for this study were therefore keen that such scenarios be included within the project scope.

In contrast to the conversion of waste-derived syngas into hydrogen, the use of biogas in fuel cells is proven at commercial scale for stationary power generation, albeit this is a process still in its infancy.[14] This report does not seek to analyse financial viability, but it should be noted in this context that scenarios coupling MBT (AD with maturation) with gas engines (in CHP mode), or with biogas-fuelled vehicles, are the highest ranked configurations which might currently be affordable to local authorities.

When coupled with H_2 fuel cells, plasma gasification (Scenarios 20 and 21) performs better than more 'conventional' gasification (Scenarios 5 and 6). This is because vendors of such plasma technologies are tending to promote oxygen (rather than air) blown gasifiers, which produce significantly more hydrogen.[15] The subsequent additional energy generated by the fuel cell offsets the greater energy use of the plasma gasifier. When coupled with a gas engine, however, the 'conventional' gasifier performs better than plasma gasification. Whilst the energy generated by the two systems is similar, the greater energy use of the plasma gasifier results in greater overall externalities, as demonstrated by the rankings for Scenarios 15(b) and 19.

Similarly, coupling gasification technologies using a gas engine (whether this is following MBT or autoclaving) demonstrates the greater efficiencies, and thus lower GHG emissions, when compared to using a steam turbine for energy generation. The positioning of Scenario 17 above Scenarios 15(a) and 16(a) also shows that combustion technologies can deliver GHG benefits over gasification if this is coupled with a steam turbine.

Perhaps surprisingly, when compared to many LCA studies, MBT ('biostabilisation') process performs better than many of the configurations generating energy due to both the lack of any release of GHGs associated with fossil carbon from energy generation and reduced emissions of methane in landfill.[16]

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[13] These technologies would include steam reforming (gas shift), pressure swing adsorption (PSA) and gas filtration

[14] A stationary 250kW Molten Carbon Fuel Cell (MCFC) designed by MTU CFC Solutions is operating at 47% electrical efficiency (in CHP mode) at an anaerobic digestion facility in Leonberg, Germany

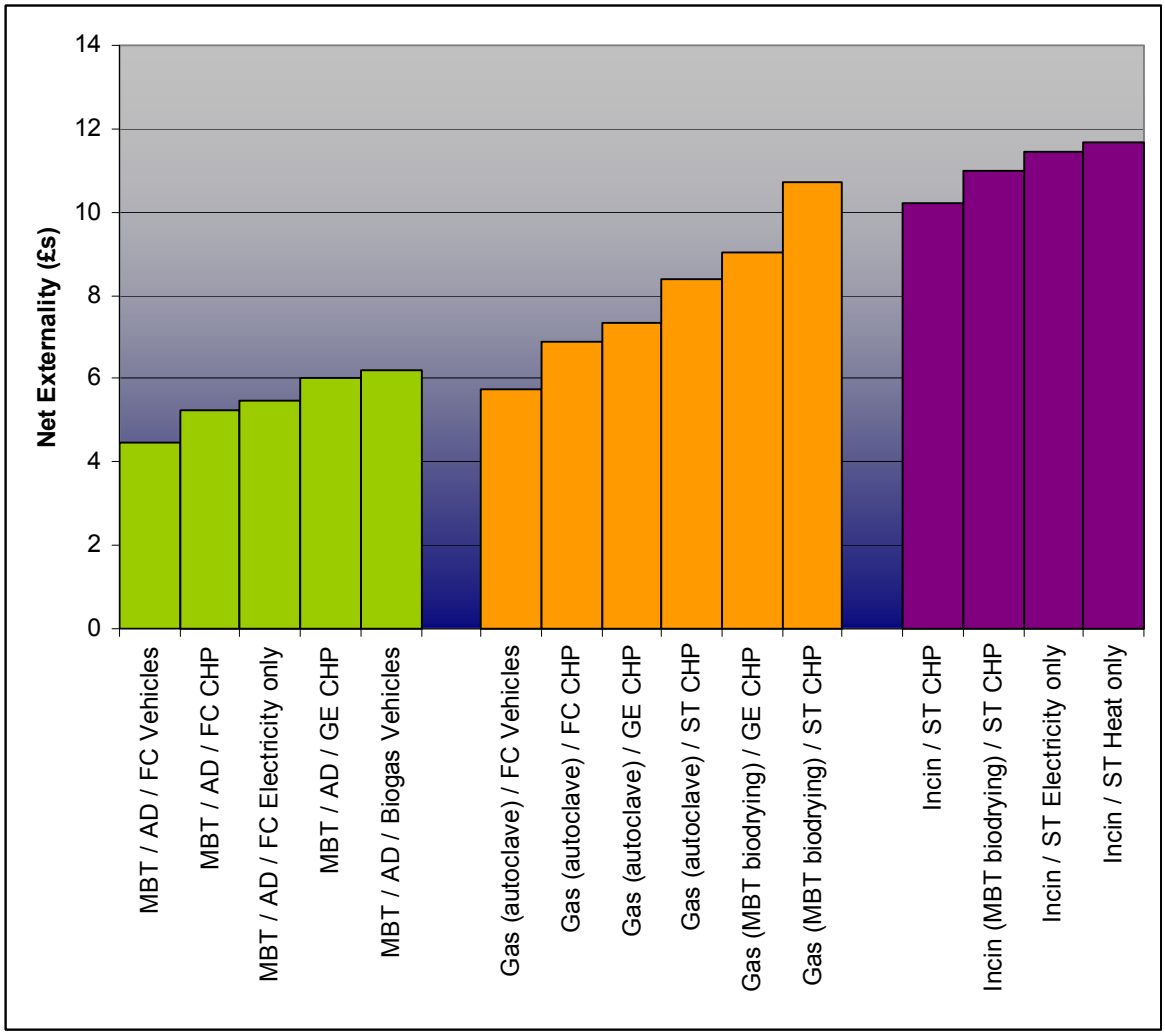
[15] It should be noted, however, that 'conventional' gasifiers could also be oxygen blown, and could thus perform better than plasma gasification if configured as such

[16] It should be noted for this scenario that a designated 'stable' landfill cell is assumed, with an active oxidation layer reducing fugitive methane emissions to a minimal level.

Whether preceded or not by MBT ('biodrying'), scenarios incorporating traditional incineration technologies perform poorly. This is the result of significant emissions from wholesale combustion of plastics at relatively low efficiencies, which negates the benefits derived from avoided emissions associated with energy generation. Only Scenario 1 (landfill with electricity only) performs at a lower level than all these scenarios, and is the only approach for which it has been assumed that no metals are recovered, which would offset emissions from manufacturing processes using raw materials.

To demonstrate and compare the performance of core technology types which can be used to generate energy, in Table A, we have highlighted the performance of all key scenarios incorporating AD, gasification and incineration. This demonstrates the better performance not only of AD over gasification and incineration, but also of fuel cells over gas engines and steam turbines. With regard to GHG balances, a key advantage of AD and gasification over incineration, therefore, is that these two technologies can be coupled with more efficient generation technologies, whilst incineration remains locked to the use of a steam turbine.

Table A: Performance of Core Technology Types under Central Assumptions



Note: FC = Fuel Cell, GE = Gas Engine, ST = Steam Turbine

Sensitivity Analysis

As mentioned above, due to the nature of this study, some of our assumptions are likely to be controversial. It should be emphasised, however, that in no way is this study intended as an academic paper, which might seek to explore every possible form of sensitivity analysis using wide ranges of potential variation in assumptions. To deliver a relevant ranking of technology scenarios and thus to function as a useful policy tool, we have therefore chosen to focus upon a limited number of sensitivities within Atropos©:[17]

1. Using a greater 'carbon intensity' for avoided electricity generation;
2. Assuming a higher degree of heat utilization from processes to displace heat from alternative sources;
3. A 'non-monetised, non-discounted' approach (but with all non-fossil CO_2 equivalents still included within the balance); and
4. A 'traditional LCA approach', with exclusion of all non-fossil emissions aside from methane from landfill.
5. Using a likely 'future' waste composition, designed to reflect higher levels of recycling.

As outlined above, there was some debate over the carbon intensity to 'ascribe' to avoided electricity generation. This was within a very limited range, however, and we have therefore restricted our sensitivity analysis for this parameter from 447g CO_2/kWh under our central assumptions, to 0.522kg CO_2/kWh, which is the value proposed in the Mayor's Climate Change Action Plan (CCAP). Perhaps unsurprisingly, the outcome of this analysis is by no means dramatic - and far less so than might occur, for example, if one was to assume the marginal avoided source of electricity generation was switching from gas to coal. As one would expect, some scenarios generating relatively higher levels of electricity move upwards as a result of the greater amount of CO_2 being avoided from alternative generation capacity. There is, however, very little noteworthy change in the rankings in that no scenario moves more than one place in either direction.

As a result of fluctuations in day/night and seasonal demand, from both residential and commercial off-takes, our central assumption is such that only 55% of heat generated by any waste management facility is used to displace alternative sources. In situations where more embedded generation might be possible, however, there is likely to be greater potential for heat use, as smaller facilities might be more easily switched on and off to accommodate local heat demand. Consequently, to provide limited sensitivity analysis on this parameter, we have raised the rate of heat utilisation to 80%. Compared to our central results, most scenarios which produce relatively large amounts of heat perform better; most notably, Scenario 4 (incineration with heat only), whilst scenarios without any heat generation fare worse. Again, however, perhaps unsurprisingly, across all scenarios the order of magnitude of change is insignificant.

The adoption of this 'non-discounted, non-monetized' approach results in little material change to the rankings when compared to those under our central assumptions. 'Slow' degrading, non-fossil carbon (i.e. lignin) sent to landfill has a greater impact when not discounted and thus all scenarios incorporating gasification (following autoclaving) move upwards at the expense of scenarios incorporating MBT (AD with maturation), which send stabilised wastes to landfill. In the bottom half of the table, however, there is no change to the rankings.

[17] See Sections 7.2.1 to 7.2.5 for full tables of results

Perhaps the most interesting and important comparison for this study (and one which in many senses represents an entirely different methodology rather than a form of sensitivity analysis) is the adoption of a typical LCA approach, the results for which have also been generated by Atropos©. The results show, however, that this has little impact on the rankings compared to our central results. Some scenarios which generate significant non-fossil CO_2 emissions through energy generation move upwards but this is usually by no more than one place in the rankings.

Changes in ranking under an LCA approach also occur partly because we have assumed – as many LCA studies do – a 100 year cut-off for the emissions. In doing so, we have attributed – which many LCAs do not do (when logically they should) – a credit in respect of non-fossil carbon still sequestered in landfill after 100 years. Also, in accounting for methane emissions from landfilled residues, we have credited back to the process those emissions which would otherwise have been associated with the carbon in the landfilled material if it had been released as CO_2 (which is consistent with the assumption that emissions of non-fossil derived CO_2 should be given zero weighting in the analysis).

Another point worth making is that effectively, to ignore most of the non-fossil carbon emissions (and how they occur over time) implies shifting the baseline. Some technologies now appear to reduce net emissions of GHGs, whilst others make net contributions to GHG emissions. It seems to us to be counter-intuitive to speak in terms of processes 'contributing to reductions in GHG emissions' when in the round, they do not.[18] To the extent that they do relies upon a particular accounting convention which is only appropriate in a limited context.

The final sensitivity tested relates to likely future changes in waste composition. In response to policy and regulatory drivers, this is likely the change significantly during the next 25 years, and thus we have modelled the impact of changing the current composition to that representative of a 45% recycling rate, as per the target set by the Mayor for 2015.[19] This impact is minimal, with only one scenario moving more than one place in the rankings compared to under our central assumptions. What should be noted, however, is that in terms of overall externalities, the Scenarios focusing on generating energy through thermal treatment processes such as incineration and gasification perform worse than under our central assumptions, whilst those scenarios employing biological treatment deliver an improved score.

Conclusions and Recommendations

As mentioned above, the goal of this study is to measure and rank a range of waste technology scenarios with regard to their performance on greenhouse gas (GHG) emissions. We do not attempt to pass judgement upon issues such as cost, planning or a host of environmental issues other than GHG emissions from waste management. Climate change, however, is recognised as a core problem facing society and therefore our conclusions and recommendations, although remaining in context, are intended to contribute to guiding waste policy development in London and beyond.

- Scenarios incorporating MBT (AD with maturation) perform most consistently well both under our central assumptions and in each form of sensitivity analysis.

[18] To suggest that waste management can reduce overall CO_2 emissions would imply that producing more waste is good for climate change, when in reality it clearly is not

[19] Greater London Authority (2006) The London Plan: Spatial Development Strategy for Greater London – Housing Provision Targets, Waste and Minerals Alterations

Currently an under-exploited approach across the UK, the GLA could bring together and integrate related research into specific planning and cost analysis, to build upon the results of this study and promote development of best-of-breed MBT (AD with maturation) facilities across the city;

- MBT (AD with maturation) delivers the greatest GHG benefit when coupled with highly efficient hydrogen fuel cell technologies. Stationary power generation using molten carbonate fuel cells (MCFCs) fueled by biogas is proven at commercial scale[20], but is currently significantly more capital-intensive than generation with more conventional steam turbines or gas engines. The case for commercial roll-out would therefore benefit significantly from the first installation of the technology within a building in London;[21]
- There has been too little research to make clear judgment as regards the potential use of fuel cells to generate energy from hydrogen converted from syngas from gasification (or plasma gasification) processes. The results of our analysis demonstrate that there is clear potential for such approaches, but we again urge caution as to the context in which they should be used. To reduce uncertainty and promote development such scenarios, the GLA should consider funding additional research of this specific area;
- The results generated by our Atropos© model have clearly shown that CHP generation delivers far greater GHG benefits than generation based upon electricity or heat only solutions. Again, there may be potential for the GLA to intervene in future planning applications to promote heat off-take in addition to electricity generation, or encourage developers to select sites which offer clear potential for embedded generation, either in communities or in industrial applications;
- Under our central assumptions and the five forms of sensitivity analysis, however, incineration with CHP reaches a high of only 15th place in the scenario rankings. The other two incineration scenarios fare worse still, and do not emerge from the bottom six positions, whilst Scenario 18, involving MBT (biodrying) prior to incineration does not fare much better. This poor performance is largely the result of wholesale combustion of plastics, which results in significant CO_2 emissions. On this basis, unless coupled with both significant kerbside recycling programmes and clear provision for good quality CHP (GQCHP), the GLA position regarding mass-burn incineration within London receives some qualified support (in that the analysis undertaken here does not cover all relevant factors and issues);
- The results from our analysis have shown that materials recycling / reprocessing, particularly of plastics, makes a considerable difference to GHG balances by avoiding emissions from virgin manufacturing processes. Compared to emissions avoided by energy generation using waste technologies, these benefits are not insignificant and are far higher than those delivered by conversion of plastics to synthetic diesel.[22] The GLA should thus ensure that they are not overlooked as a result of related stakeholders' desire to meet targets for installed 'renewable' energy capacity;

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[20] One such facility is operating in Leonberg, Germany

[21] Toward this end, the GLA and London Climate Change Agency are considering potential installation of a MCFC at a regional government office building in London

[22] As can be seen from the detailed breakdown of results provided in Appendix 5

- This study has shown that autoclave technologies, if implemented and operated as planned by technology suppliers, have potential to be part of relatively well performing scenarios. As stated above, this study is not concerned with assessing the technical viability of particular technologies. Until autoclaving has been commercially proven in the UK, however, only limited conclusions should be drawn from this particular aspect of our analysis;
- It should be acknowledged that the maturation time of reject streams from 'pre-treatment' technologies such as MBT and autoclaving has a key impact on scenario performance. As outlined for each technology in Section 6.0, we have set these maturation times according to how they are being presented by bidders for local authority procurement contracts. In reality, however, all scenarios can be tweaked to incorporate greater or lesser maturation times according to the Landfill Allowance Trading Scheme (LATS) requirements of a particular authority.
- A key point ot note is that under our central assumptions, the difference in GHG-related externalities between the first 10 scenarios is, in monetary terms, only £3.05 per tonne of input waste. This would indicate that based upon the assumptions used within this study, should any of these scenarios incur significant capital or operating expenditure above the others, it is unlikely to be justifiable through reference to GHG-related externalities alone. It should be highlighted, however, that there are wide-ranging estimates of the SCC, as discussed in Section 3.3.[23] Thus, if higher values had been employed within Atropos©, this difference in externalities between the first 10 scenarios might have been significantly greater; although similarly if a lower SCC had been modelled, far smaller differences would have been recorded; and
- Finally, although there is still further research to be undertaken, this study has shown that new technologies can deliver far lower GHG emissions than using conventional incineration or landfill. As the potential to utilise hydrogen fuel cell technology develops, and becomes more affordable, such benefits are likely to increase further.

[23] Also, discussed in more detail in Appendix 3

6.2 Incineration

Incineration involves the combustion of residual MSW in the presence of oxygen, usually on a 'moving grate'. Typically, incineration plant temperatures are in excess of 850ºC and the waste is converted into carbon dioxide and water. As not all waste burns, a proportion falls through the grate as ash. This 'bottom ash' contains all the steel and aluminium that entered the plant and so magnets and other equipment can be used to separate the former for recycling. The remaining ash is either sent to landfill or used in construction materials.

Incineration is a relatively well-established technology for the treatment or disposal of municipal solid waste in the UK. As a result, the assumptions associated with its use are perhaps less arguable than those for other, lesser-known technologies. A key point of discussion, however, in modeling the GHG impacts of incineration is the efficiency of energy recovery from the input waste stream. The approach undertaken in this study largely echoes that previously undertaken by Eunomia,[94] which highlights the importance of net energy production and the distinction between net and gross calorific values (CVs).

The efficiency of generation of electricity by an incinerator should be calculated net of any energy used in the plant itself. The energy use in the plant depends for the most part upon the nature of the flue gas cleaning system used, but also upon a range of other factors. The relationship to flue gas cleaning is important since it seems likely that as standards for abatement have improved, so the energy used in achieving those levels of abatement has increased also. For facilities currently being built, it would appear that internal use of energy accounts for around one sixth of electricity actually generated. We assume in the modelling an energy use of 92kWh per tonne of input based on using a bag filter with semi-dry acid gas removal, SNCR (De-Nox) and dioxin removal (activated carbon).

The distinction between the gross or net calorific values (GCVs or NCVs) of the input waste is equally important, as basing estimates on the latter would result in efficiencies inflated beyond achievable performance levels. There have been a number of recent studies published in the UK, which make estimates of efficiencies for incineration, but there appears to be some confusion with regard to their basis:

- ERM on behalf of Defra[95] uses an implied efficiency of 28% relative to reported NCVs. This is a gross figure and the energy use was 0.118kg of diesel plus 3.91kWh of electricity. No justification for these figures is provided in the report;
- Oakdene Hollins on behalf of the Institute of Civil Engineers (ICE)[96] used a figure of 25.4%. This was based upon work by C-Tech which reports this efficiency relative to NCVs. The study for the ICE appears to have applied the

[94] Eunomia (2006) *A Changing Climate for Energy from Waste?* Final report to Friends of the Earth, May 2006

[95] ERM (2006) *Carbon Balances and Energy Impacts of the Management of UK Wastes*, Final Report for Defra, December 2006

[96] Oakdene Hollins (2005) *Quantification of the Potential Energy from Residuals (EfR) in the UK*, Report for the Institute of Civil Engineers and the Renewable Power Association, March 2005

efficiency figure to GCVs, consequently overstating the potential for electricity recovery;

- Fichtner, in a report for ESTET[97] quoted net electrical efficiencies for steam cycle combustion of 19-27% based upon NCV;
- CIWM reports efficiency of generation of 22%-25%, but this does not make reference to any measure of the CV used.[98]
- CEWEP indicates that for a sample of 28 plants producing *mainly* electricity, the net electricity generation averaged 17.7% with 2.6% of heat energy exported. For electricity generation, plants generating *mainly* electricity exhibited a range in their efficiencies of net export from 8.4% to 24.3%.[99]

The above estimates can in many ways be considered "theoretical" in that most are not based upon performance data from operational facilities. When compared to estimates of efficiencies from wider studies, which use data from "actual" facilities, they appear somewhat high.

As part of the development of the Best Available Technology (BAT) standard for incineration as part of the EU Best Available Reference (BREF) document for waste treatment processes, measurements were made at 8 German plants and efficiencies ranged from 12.9% - 22%, with an average of 18%. However, this did not account for the plant's own use of electricity, which reduced net efficiencies to 8.7% - 18%, with an average of 13%.[100] The BREF document also noted that for new French facilities, efficiency of production was 16.4%, with net efficiencies at 13.4%[101], whilst a recent report for the German Umweltbundesamt stated an efficiency of approximately 21% in terms of gross output.[102]

As shown in Table 6-2, we feel, however, that it is prudent to base our central analysis upon an estimate of 25% efficiency (NCV). This is at the high-end of efficiencies of plants currently in operation.[103]

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[97] Fichtner Consulting Engineers Limited (2004) *The Viability Of Advanced Thermal Treatment Of MSW In The UK*, ESTET, March 2004

[98] CIWM (2003) *Energy from Waste: A Good Practice Guide*, Northampton: IWM Business Services Group, November 2003

[99] Dieter O Reimann (2006) *Results of Specific Data for Energy, Efficiency Rates and Coefficients, Plant Efficiency factors and NCV of 97 European W-t-E Plants and Determination of the Main Energy Results*, Report to CEWEP, Updated July 2006

[100] Energysub-group (2002) Energy Recovery from Waste Incineration Plants, cited in European Commission (2005) Integrated Pollution Prevention and Control: Reference Document on the Best Available Techniques for Waste Incineration, July 2005

[101] European Commission (2005) Integrated Pollution Prevention and Control: Reference Document on the Best Available Techniques for Waste Incineration, July 2005.

[102] Dehoust et al (2005) *Status Report on the Waste Sector's Contribution to Climate Protection and Possible Potentials*, Research Report 2005 33 314, UBA-FB III, German Federal Environmental Agency, August 2005

[103] As discussed in the main body of the text, this is above the net efficiencies used in the recent German study, and well above the higher end efficiency looked at in the report for CEWEP. However,

A final point that should be noted is the presence of biodegradable carbon within the ash from moving-grate incineration. Research has shown that bottom ash is likely to result in some emissions of CO_2 and CH_4 once in landfill.[104] It should be acknowledged that although these emissions will be relatively small, and thus represent a level of detail beyond the scope of this study, should incineration form part of any further analysis to consider a hierarchy of options in more detail, we would propose to include these emissions within our Atropos© model.

Table 6-2: Summary of central assumptions for Incineration

Parameter	Assumption
Net electrical efficiency (electricity only mode) based upon NCV	25%
Net electrical efficiency (CHP mode) based upon NCV	16%
Heat efficiency (CHP Mode) based upon NCV	50%
Heat efficiency (Heat only mode) based upon NCV	90%
Electricity demand for flue gas cleaning	92kWh/t input
Recovery rate for ferrous metals from bottom ash	60%
Bottom ash production	21%

6.3 Gasification

Gasification is a far newer technology than incineration for the treatment or disposal of waste. It involves the partial oxidation of waste. This means that oxygen is added but the amounts are not sufficient to allow the fuel to be completely oxidised and for full combustion to occur. The temperatures employed are typically above 750°C. The main product is a syngas, which contains carbon monoxide, hydrogen and methane. The CV of this syngas will depend upon the composition of the input waste to the gasifier. The other main product produced by gasification is a solid, non-combustible 'char'.

Gasification has received significant recent attention in the municipal waste market as a potential alternative to incineration, but thus far only two commercial-scale facilities have planning permission and none are currently operating only on MSW or MSW-derived feedstocks in the UK.[105] There are, however, a handful of facilities

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one facility operating in Amsterdam, reports a net efficiency close to 30%, and this relies on a range of process adaptations including the use of intermediate superheating

[104] From Hanne L. Erichsen and Michael Hauschild (2000) *Technical Data for Waste Incineration - Background for Modeling of Product Specific Emissions in a Life-cycle Assessment Context*, April 2000, S. Dugenest, H. Casabianca and M.F. Grenier-Loustalot (1999) *Municipal solid waste incineration bottom ash: Physicochemical characterization of organic matter*, D. P. Komilis R. K. Ham R. Stegmann (1999) *The effect of municipal solid waste pretreatment on landfill behavior: a literature review*, Waste Management and Research, Volume 17 Issue 1 Page 10 - February 1999

[105] Permission has been granted for the construction of a Novera / Enerkem gasification facility in East London and for the construction of a Compact Power pyrolysis/gasification facility in Avonmouth, Bristol

operating at commercial scale within the EU, although these are not always treating a mixed waste stream, along with many high-temperature facilities in Japan. In many cases, gasification technologies are planned to treat refuse-derived fuels (RDF)[106] from MBT or autoclave facilities,[107] as is the case for a facility planned for East London Waste Authority.

Performance data is therefore perhaps less reliable than that for incineration, especially if operating in CHP mode, upon which this study focuses. As a result, we have based our central estimates of efficiencies in Table 6-3 on information provided only by technology providers which have commercial-scale facilities already operating in other EU Member States. Again, it is important to present these figures according to the NCV of input waste, and separate to any energy used by the process itself. Once more, our assumptions are based on mass flows and energy balances quoted by technology providers. The figures quoted in Table 6-3 are based on gasification of RDF produced by a MBT (biodrying) process as is discussed in Section 6.5.2.

Table 6-3: Summary of central assumptions for gasification

Parameter		Assumption
Boiler/Steam turbine	Net electrical efficiency (electricity only mode)	25%[1]
	Net electrical efficiency (CHP mode)	18%[1]
	Heat efficiency (CHP Mode)	48%
Gas engines[2]	Net electrical efficiency (electricity only mode)	35%[1]
	Net electrical efficiency (CHP mode)	35%[1]
	Heat efficiency (CHP Mode)	36%
Electricity demand for flue gas cleaning		72kWh/t input
Carbon content of char		10%
Biodegradable carbon content of char		0%

Notes:

1. It should be noted that the efficiencies quoted relate to the power generation (steam turbine or gas engine) element of the process only. To determine overall system efficiencies, the efficiency of conversion of the waste to syngas within the gasification chamber must also be taken into consideration. If this efficiency (taken from our Atropos© model) is applied to the efficiencies of the power generation phase, the overall system efficiencies for each of the above (from top down) are 17%, 11%, 25% and 25% respectively
2. As noted in Section 6.2 for incineration, we have positioned our analysis at the high-end of likely generation efficiencies. With some systems we acknowledge there may be technical difficulties to achieving such levels

[106] Also often know as solid-recovered fuels (SRF)

[107] Discussed in Section 6.6