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RDF Export

Analysis of the Legal, Economic and Environmental Rationales

November 2015

Report for RDF Export Industry Group

Prepared by Eunomia

Report for The RDF Export Industry Group

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Acknowledgements and Report Context

Our thanks to the following members of the RDF Export Group, which participated in the development of this report: AEB Amsterdam BV, Andusia Recovered Fuels Ltd, Attero BV, Biffa Group Ltd, F & R Cawley Ltd, CWM, EEW Energy from Waste, EFO AB, FCC Environment Ltd, Gemi UK Ltd, GMVA GmbH (Remondis), New Earth Solutions Group Ltd, Seneca Environmental Solutions Ltd, Shanks Waste Management Ltd, swb Entsorgung, Totus Environmental Ltd, Twence BV, Veolia plc, William Tracey Group Ltd.

It should be acknowledged that whilst general consensus has been reached on the central findings of the study, not all members agree with and support all specific comments within the report.

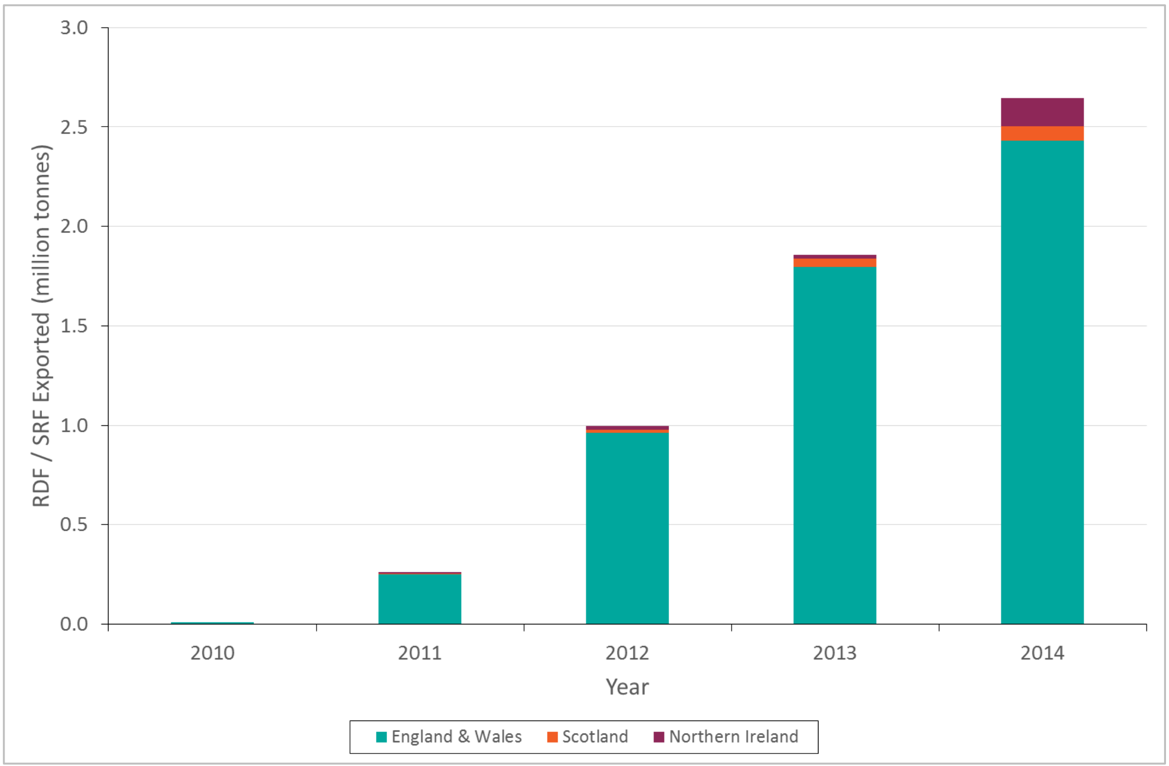
Cover photo courtesy of Pembrokeshire County Council.

Executive Summary

This report has been prepared by Eunomia Research and Consulting ('Eunomia') on behalf of the Refuse Derived Fuel (RDF) Export Industry Group ('the RDF Group').[1]

There has been a significant increase in the amount of UK waste being exported to mainland Europe as RDF since 2010. RDF exports from the UK have increased from just 0.01 million tonnes in 2010 to 2.6 million tonnes in 2014, as shown in Figure E-1.

Figure E-1: RDF Exports from UK 2010-2014 (Calendar Years)



[1] The Group comprises, AEB Amsterdam BV; Andusia Recovered Fuels Ltd; Attero BV; Biffa Group Ltd; F & R Cawley Ltd; EEW Energy from Waste; EFO AB; FCC Environment Ltd; Gemi UK Ltd; GMVA GmbH (Remondis); New Earth Solutions Group Ltd; Seneca Environmental Solutions Ltd; Shanks Waste Management Ltd; swb Entsorgung; Totus Environmental Ltd, Twence BV; Veolia plc and William Tracey Group Ltd.

Over the same time period the Netherlands has been the destination receiving the largest quantity of waste (1.3 million tonnes in 2014), although the proportion of waste going to Sweden (0.5 million tonnes in 2014) and Germany (0.5 million tonnes in 2014) is increasing year-on-year.

This considerable rise in exports, and Defra's response (on 1st December 2014) to its Call for Evidence on the RDF export market in England, prompted the initiation of the RDF Group.[2]

The RDF Group welcomes Defra's desire to work with industry, and the purpose of this study is to provide an evidenced-based report, supported by the Group, to present the opportunities and issues around RDF export, including consideration of the legal, environmental, and economic case for (and against) RDF export. With regard to legal issues, the RDF Group has obtained advice from a Queen's Counsel (QC) in relation to the practical application of specific aspects of relevant EU and UK legislation, and the related elements of the report draw upon that advice.

The key messages from the evidence presented in the report can be summarised as follows:

- Within existing legislation, there is only limited legal basis for any kind of treatment 'standard' to be introduced for exported RDF and this would be challenging and costly (both to Government and industry) to enforce. The basis for this standard would have to relate to the application of the waste hierarchy, which would need to apply equally to residual waste treated domestically:
    - The Group does not want to discourage operators from recovering more materials from the residual stream. However, a more cost-effective and environmentally preferable approach to enforcing the hierarchy would be for Defra and the EA to focus on regulating and incentivising the greater capture of recyclable materials (including food waste) at source, from both local authority and commercial and industrial (C&I) wastes;
    - Defra and the EA should therefore consider how this might be achieved through better enforcement of the regulations, and work with industry to determine the impacts of such recycling upon residual waste composition, such that this can continue to be effectively treated at both domestic waste treatment facilities and overseas R1 plant;[3]

[2] Defra (2014) *Refuse derived fuel market in England: Defra response to the call for evidence*, December 2014

[3] R1 is an energy efficiency standard which energy from waste (EfW) facilities must meet to be able to legally process RDF from another EU Member States. For further information on the standard, see http://ec.europa.eu/environment/waste/framework/pdf/guidance.pdf

    - In the context of encouraging recycling at source, an advantage of RDF export is its flexibility. RDF export to overseas facilities has the potential to enable parts of the UK to leapfrog lower levels of the waste hierarchy by providing a flexible treatment route rather than one which often requires long-term guaranteed tonnages of waste. Investment in waste infrastructure in the UK should not be discouraged, rather it is important to focus on the right type and scale of infrastructure that is needed.
- In terms of environmental impacts and benefits, the life-cycle assessment (LCA) of five residual waste management scenarios within this study suggests that:
    - It is hugely important, in environmental terms, to use the heat generated via recovery of energy from waste, either in district heating applications or in industry, as part of combined heat and power (CHP) configurations;
    - Transport is a very minor contributor to total carbon dioxide (CO_2) emissions. Whilst the emissions from transport are four times greater in the export scenarios (than in the UK scenarios), these still only account for just 3% of total emissions;
    - Even when the shipping distance is increased by 1,700 miles, total emissions for the export scenarios only rise by 1%. At the same time, whilst back-hauling RDF means that there are effectively no emissions from shipping, total emissions fall by less than 1% under such scenarios;
    - Increasing the level of materials recovery during the RDF pre-treatment phase results in a material improvement in the performance of such scenarios;
    - Assumptions relating to the carbon intensity of energy which is 'displaced' by that generated by recovery of energy from waste can have a significant impact upon the results of LCA of this nature; and
    - Ultimately, the relative performance of RDF export scenarios and domestic scenarios depends upon the specific nature of the infrastructure used. The results of this analysis, however, demonstrate that RDF export is currently unlikely to result in any net increase in CO_2 emissions from residual waste treatment.
- There are both costs and benefits in terms of the economic impacts of RDF export. As well as potential losses from the UK economy in terms of gate fee revenue (largely for landfill operators at present), there are additional factors at play, at different stages of the waste management chain for producers, contractors and the wider economy:
    - RDF export has not only increased competition in the market, exerting some downward pressure on gate fees paid by UK producers of waste to UK operators, but has also provided a lower cost outlet for both businesses and local authorities;

    - The loss in gate fee income to domestic landfill (and in the future, waste treatment) operators is to some extent offset by revenue generation by other (or the same) operators along the RDF production and supply chain;
    - Whilst some UK jobs may be lost due to RDF export there are alternative employment opportunities created in waste collection and transfer, and at portside for the handling of RDF from delivery to loading of cargo vessels;
    - Landfill tax receipts fall as a result of RDF export. However, their contribution to overall taxation receipts is minimal. There is also a 'circularity' to this issue as RDF export means that local authority waste services require less funding due to the lower gate fees available. As a result less central Government funding is required, which to some extent offsets the loss of Landfill Tax revenue.
- Defra's recent consultation on waste crime included issues relating to RDF export and the RDF Group submitted a formal response to this consultation.[4] The RDF Group's consultation response is summarised within this report. In essence, the RDF Group has made a series of recommendations for new measures to tackle illegal activities that are often suggested to be associated with the RDF export market. These include:
    - Powers to suspend permits for non-compliance;
    - Powers to issue notices to avoid permit breaches;
    - Modification of the nature of permits;
    - Greater focus on non-permitted sites;
    - Powers to physically intervene;
    - Improved funding of the Regulator; and
    - Better management control of ownership of waste.
- There is no link between the legitimate growth of the RDF export industry and cases of waste being abandoned and sometimes ignited. RDF export requires tracking of waste through Trans-Frontier Shipment (TFS) certificates. As such a mechanism is already in place requiring operators exporting waste to comply with the notification controls procedure. Waste that is abandoned or ignited in the UK, most of which isn't the subject of TFS certificates, is not destined for export. Although such cases are cited as the malign effect of waste export, they would be better understood, and regulated, as a matter of domestic non-compliance and enforcement;
- If the total residual waste that is suitable for recovery, but which is currently sent to landfill, in the UK (14.7 million tonnes) was treated at domestic R1

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[4] Defra (2015) *Waste crime: consultation on proposals to enhance enforcement powers at regulated facilities; and call for evidence on other measures to tackle waste crime and entrenched poor performance in the waste management industry*, February 2015

facilities, it would amount to both 3% of total generation and 6% of renewable generation (based on our calculations of the renewable fraction of residual waste). More importantly, if the 2.6 million tonnes of RDF exported in 2014 was treated at domestic R1 plant, this would contribute around 0.5% to total UK electricity generation and around 1% to total UK renewable electricity generation.

In conclusion, the evidence presented in this study strongly suggests that the legal framework does not provide for any sensible means of Government intervening to set a restrictive standard for exported RDF. Furthermore, the environmental and economic impacts of RDF export are not wholly dissimilar from domestic treatment of residual waste. Such analysis might be further informed by a more detailed Government Impact Assessment (IA).

Contents

1.0 Introduction

This report has been prepared by Eunomia Research and Consulting ('Eunomia') on behalf of the RDF Export Industry Group ('the RDF Group').

1.1 Background to the RDF Group

The RDF Group has been brought together to explore the opportunities and issues relating to RDF export. The formation of the group was prompted by Defra's response (on 1st December 2014) to its Call for Evidence on the RDF export market in England.[5] In the response Defra set out its desire to work with the industry.

The purpose of RDF Group is to collectively:

- Explore and address issues surrounding RDF export from the UK and related topics;
- Develop evidenced-based information on the legal, environmental and economic issues related to RDF export; and
- Communicate its work to third parties including the government and other key stakeholders.

The Group comprises the following members:

1) AEB Amsterdam BV;
2) Andusia Recovered Fuels Ltd;
3) Attero BV;
4) Biffa Group Ltd;
5) CWM Environmental Ltd;
6) F & R Cawley Ltd;
7) EEW Energy from Waste;
8) EFO AB;
9) FCC Environment Ltd;
10) Gemi UK Ltd;
11) GMVA GmbH (Remondis);
12) New Earth Solutions Group Ltd;
13) Seneca Environmental Solutions Ltd;
14) Shanks Waste Management Ltd;
15) swb Entsorgung;
16) Totus Environmental;

[5] Defra (2014) *Refuse derived fuel market in England: Defra response to the call for evidence*, December 2014

17) Twence BV;
18) Veolia plc; and
19) William Tracey Group

1.2 Purpose of this Report

The RDF Group welcomes Defra's desire to work with industry, and the purpose of this study is to provide an evidenced-based report supported by the Group, to present the opportunities and issues around RDF export. This includes consideration of the legal, environmental, and economic case for (and against) RDF export.

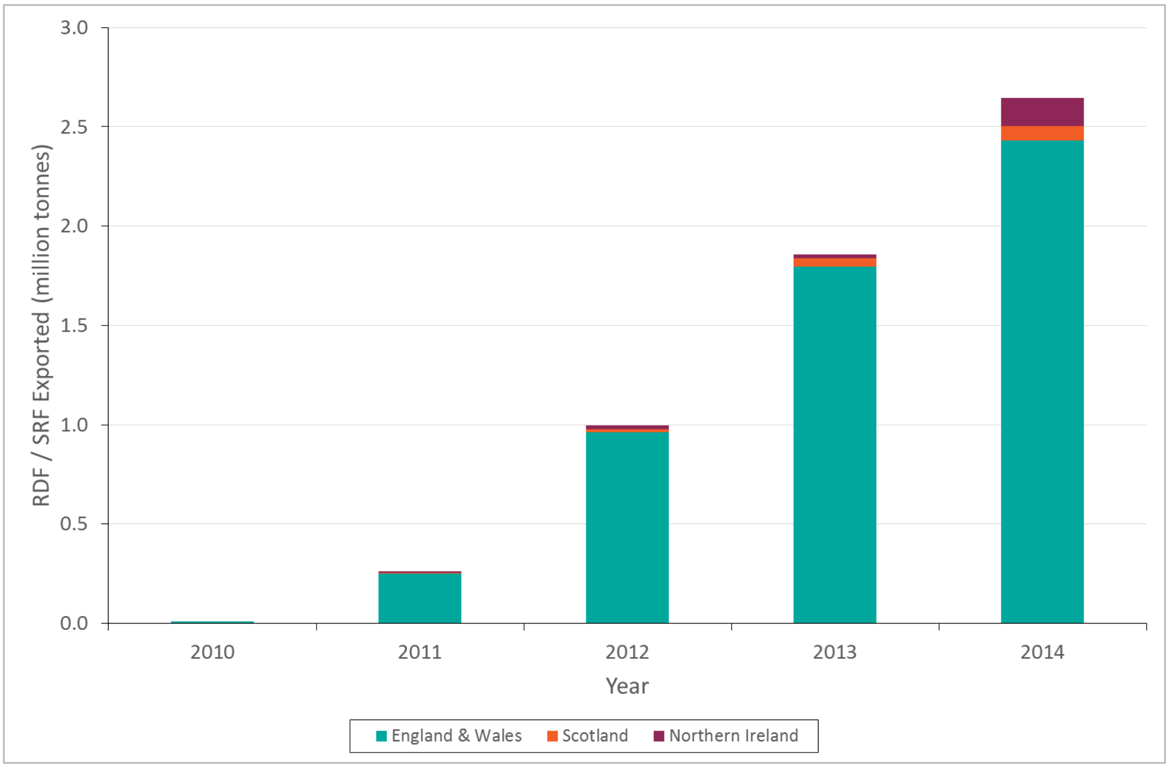
Based on the evidence presented, the report includes a series of recommendations surrounding the practice of producing and exporting RDF. If these recommendations are followed, the RDF market may maximise environmental and economic benefits, whilst operating in accordance with existing legislation and the overarching principles of the waste hierarchy.

1.3 Growth in RDF Exports

There has been a significant increase in the amount of UK waste being exported to mainland Europe as RDF since 2010. As shown in Figure 1.1. Furthermore, during the first quarter of 2015, 0.7 million tonnes of RDF was exported from England alone, showing a continuation of this increasing rate.

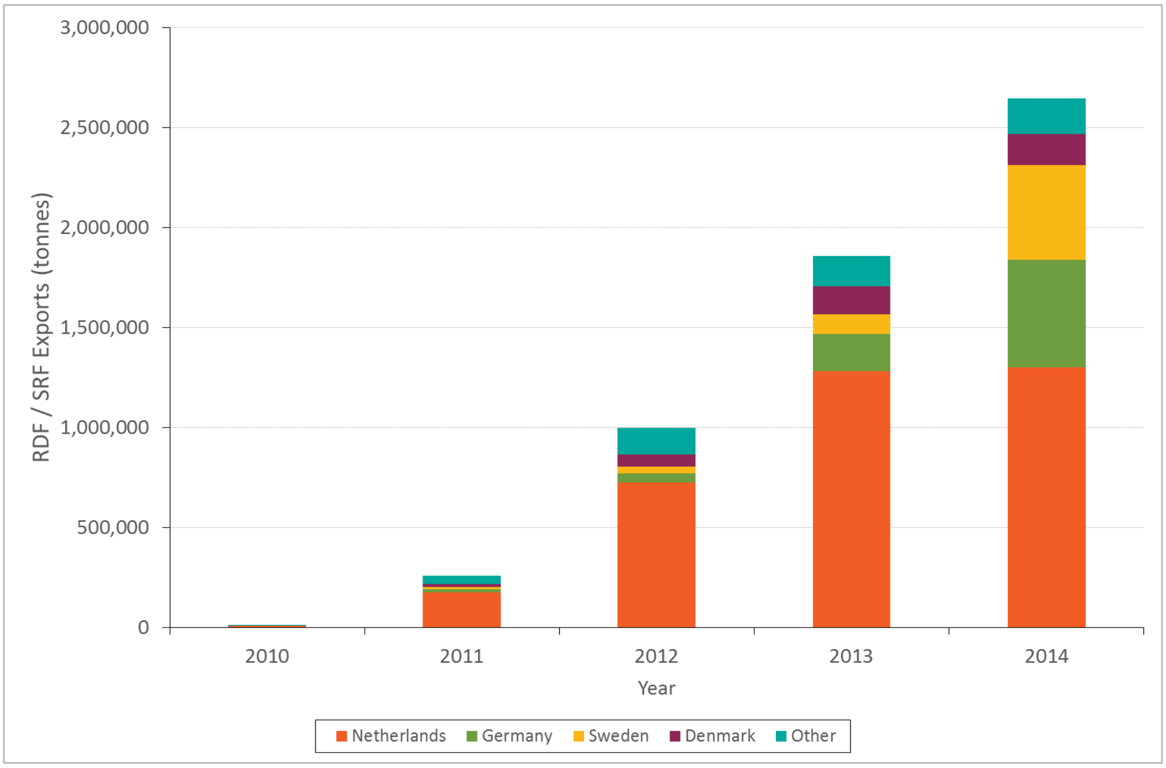
With landfill at over £100/tonne (including Landfill Tax) in most regions, it's perhaps unsurprising that operators are exporting both residual local authority collected (LAC) and commercial and industrial (C&I) wastes to take advantage of lower gate fees at European incinerators with spare capacity.

Figure 1.1: RDF Exports from UK 2010-2014 (Calendar Years)



Over the same time period the Netherlands has been the destination receiving the largest quantity of waste, although the proportion of waste going to Sweden and Germany is increasing year-on-year, as shown in Figure 1.2.

Figure 1.2: RDF Exports by Destination 2010 – 2014 (Calendar Years)



2.0 The Legal Context

This section sets out the legislative framework relating to the export of RDF from the UK to other EU Member States (MS). The RDF Group has obtained advice from a Queen's Counsel (QC) in relation to the practical application of specific aspects of relevant EU and UK legislation, and this sections draws heavily upon that advice. On this basis, the Group has also provided practical 'recommendations' to inform any future Government policy in this specific area.

2.1 Legislative Framework

The transport of waste between EU MS is regulated by:

- Regulation (EC) No. 1013/2006 on Shipments of Waste ('the WSR'); and
- Directive 2008/98/EC on Waste ('the Revised Waste Framework Directive' or 'WFD').

These EU instruments have been transposed into UK law by:

- The Transfrontier Shipment of Waste Regulations 2007/1711 (as amended) ('the TFS' Regulations); and
- Waste (England and Wales) Regulations 2011/988 (as amended) ('the Waste Regulations').

The main focus of the analysis in this section is upon these pieces of legislation.

2.1.1 Procedure of Prior Notification and Consent

The WSR provides that shipments of certain wastes between MS for recovery operations are subject to prior written notification and consent. The WSR sets outs the procedure of prior written notification and consent, which can be summarised as follows:

- Notification (Article 4) – the 'notifier' (i.e. the entity exporting the RDF) submits a prior written notification to the 'competent authority of dispatch' (for example, in the case of England, the Environment Agency - EA);
- Transmission of the notification (Article 7) – once the notification has been made, the competent authority of dispatch must notify the 'competent authority of destination' (for example, the Dutch, German or Swedish equivalents to the EA) and, if applicable, the 'competent authority of transmission' (i.e. any countries through which the RDF will travel);
- The competent authority of dispatch may decide, within three working days, not to proceed with the notification, if it has objections to the shipment in accordance with Articles 11 and 12 (explored in Section 2.1.3);
- When the competent authority of destination considers that the notification has been properly completed, it should send an acknowledgement to the notifier, which is copied to the other competent authorities concerned;
- The competent authorities of destination, transmission and dispatch shall have 30 days following the date of transmission of the acknowledgement by

the competent authority of destination (in accordance with Article 8) during which to take one of the following duly reasoned decisions in writing as regards the notified shipment:
   - Consent without conditions;
   - Consent with conditions in accordance with Article 10; or
   - Objections in accordance with Articles 11 and 12.

The notifier may submit a general notification to cover several shipments if in the case of each shipment:

- The waste has essentially similar physical and chemical characteristics; and
- The waste is shipped to the same consignee and the same facility; and
- The route of the shipment as indicated in the notification document is the same.

Duration of Export Notices

The duration of export notices is important in the context of longer-term municipal contracts for RDF offtake. Whilst the C&I market works on a more flexible, short-term basis, the nature of local authority procurement process and contracts means a longer term contract agreement is usually desirable. This can pose difficulties if the notifier/exporter is unable to secure a notification for the entire duration of the contract.

If, in England for example, the EA grants a notification, then it will expire one year after it is issued, unless the EA indicates that a longer or shorter period will apply by specifying this in the notification document. The EA has a discretion to fix the period of validity of the consent, and therefore may choose to grant RDF export licences for a period of 1 or 3 years, or for a longer or shorter period.

2.1.2 Classification of Waste

In the UK, the UK Plan for Shipments of Waste, effectively prohibit exports of 'mixed municipal' waste (EWC code 20 03 01) for recovery, making the classification of waste an important factor in the application of the TFS Regulations.[6] It should be noted that other MS, including for example Republic of Ireland, have interpreted the WSR differently and allow mixed municipal waste to be exported. In relation to the export of treated residual waste from the UK, waste can be exported under the following EWC codes:

- 19 12 10 (Combustible waste - Refuse Derived Fuel); and

[6] Defra (2012) *UK Plan for Shipments of Waste*, May 2012

- 19 12 12 (other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11 (hazardous)).

In November 2013, the Northern Ireland Environment Agency (NIEA) published a Regulatory Position Statement (RPS), which was updated in March 2014, in which it prescribed some examples of the type of treatment that waste must undergo before the NIEA considers that the mechanical treatment of mixed municipal waste has resulted in waste which can be classified under EWC codes 19 12 10 or 19 12 12. The RPS was based on Recital 33 of the WFD which states that:

> *For the purposes of applying Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments of waste, mixed municipal waste as referred to in Article 3(5) of that Regulation remains mixed municipal waste, even when it has been subjected to a waste treatment operation that has not substantially altered its properties.*

However, it is important to understand the legal standing of a 'Recital' in this instance. The terms set out in Recital 33 have not been introduced as an operative provision of the WFD, nor have they been introduced as an operative provision of the WSR, and they do not therefore constitute a rule. The WFD and the WSR, set out a comprehensive code of the applicable rules which cannot be derogated from, or added to, by a Recital.

Defra states, within its response to its recent Call for Evidence, that it will:

> *Propose to investigate further the feasibility of introducing a definition and treatment standard for RDF, what these might cover and how they might be delivered.*

The response refers directly to the NIEA RPS and suggests that:

> *This could be used as a starting point for considering what the treatment standard should cover and what is required. Thought will also need to be given as to whether a definition and treatment standard can be delivered through guidance or whether legislation is necessary.*

Given the case set out above, it is highly unlikely that Defra could impose a prescriptive treatment standard relating to the classification of waste within the existing legislative framework, as it appears to propose. The transferee and transferor have a duty of care to determine the EWC.

Classification of Waste

Within existing legislation, there is no legal basis for competent authorities (for example, the Environment Agency) to impose prescribed treatment requirements for waste to be classified as EWC 19 12 10 or 19 12 12 for export as RDF.

2.1.2.1 Potential Disputes over Waste Classification

The WSR does not appear to make any provision for how to resolve a dispute between the competent authority and the notifier/exporter over how the waste should be classified. Article 28 ('Disagreement on classification issues') applies to disagreements between competent authorities.

Irrespective of the composition of RDF, it falls under the scope of Annex IV of the WSR, or a mixture of waste not classified under a single entry in Annexes III or IV. Consequently, this means that the procedure of prior written notification and consent, as outlined in Section 2.1.1, would still apply. The competent authority could therefore refuse to grant its consent only if it could rely on one of the grounds in Article 12, as discussed in Section 2.1.3.

2.1.3 Scope for Objection to Export Notifications

The WSR sets out the procedure that must be followed for prior written notification and consent, as described in Section 2.1.1. If the notifier/exporter complies with the necessary steps of the procedure, then the EA (or other competent authority) must:

- Grant consent without conditions;
- Grant consent with conditions in accordance with Article 10; or
- Object in accordance with Articles 11 and 12.

Article 11 of the WSR is concerned only with shipments of waste for disposal and is therefore not relevant in the context of the export of RDF to R1 facilities. The EA could only object to the shipment, therefore, if it could rely on one or more of the grounds in Article 12 of the WSR.

Under Article 12, the competent authority could object to the shipment of waste if this is not in accordance with

- National legislation relating to environmental protection;
- Public order, public safety or health protection concerning actions taking place in the objecting country; or
- National legislation in the country of dispatch relating to the recovery of waste.

On this basis, it appears that the EA (or another competent authority) might have a legitimate case to object to the export of waste with the reasoning that the waste would not be treated in line with the Waste Hierarchy as set out in Article 4 of the WFD. This is because:

- Article 10 of the WFD states that MS should take the necessary measures to ensure that waste undergoes recovery operations in accordance with Article 4;
- The Waste Hierarchy has been transposed into UK law through the Waste (England and Wales) Regs 2011, SE 2000/988, Regulations 12, 15 and 35; and
- This is UK legislation within Article 12 (1)(b) of the WSR.

This suggests that should Defra believe there is sufficient evidence to suggest that the practice of exporting RDF results in a situation that deviates from the waste hierarchy (more than might otherwise be the case), it would have a legal basis to support the introduction and enforcement of a treatment standard.

Any such standard, however, would not only need to clearly set out the requirements that the EA considered necessary to meet the waste hierarchy, but would also need to be applied to *all* wastes which are subsequently processed at recovery facilities, whether in the UK or overseas. This is because the introduction of a legislative requirement to process residual waste (to produce RDF) in a specific way for treatment at an R1 facility in other MS (but not in the UK) would disadvantage undertakings which are not able to process waste in a specific way and thus be contrary to EU Law.

In the case of public undertakings, a MS must not adopt any measure contrary to the rules contained within the TFEU: TFEU Article 106(1). These rules include the competition provisions, and the free movement of goods provisions, and, in particular, TFEU Article 35, which suggests that subject to Article 36, quantitative restrictions on exports, all measures having equivalent effect, shall be prohibited between MS.

Objections to Notifications

Defra could introduce a treatment standard for RDF based on the need to adhere to the waste hierarchy, but to be in compliance with EU Competition Law, it might need to introduce the same standard for all residual wastes sent for recovery both in the UK and other MS.

2.2 Recommendations

Based on the above analysis, which as mentioned previously, is based on a legal opinion from a QC, the RDF group makes the following recommendations, which might inform Defra's ongoing consideration of this policy area:

- There is only limited legal basis – primarily related to the waste hierarchy – for any kind of treatment 'standard' to be introduced for exported RDF. Furthermore, it appears that any such standard would also need to be applied to waste being incinerated in the UK. This would be extremely challenging and costly (both to Government and industry) to enforce;
- The basis for this standard would have to relate to the application of the waste hierarchy. The Group does not want to discourage operators from recovering more materials from the residual stream, for example via mechanical sorting or more sophisticated MBT. However, a more cost-effective and environmentally preferable approach to enforcing the waste hierarchy would be for Defra and the EA to focus on incentivising the greater capture of recyclable materials (including food waste) at source prior to them

entering residual waste streams, and from both local authority and commercial and industrial (C&I) wastes; and

- Defra should therefore consider how this might be achieved, and work with industry to determine the impacts of such recycling upon residual waste composition, such that it can continue to be effectively treated at waste treatment plants including incineration and advanced thermal treatment (ATT) facilities whether domestic or overseas.

3.0 Environmental Context

The environmental impacts of exporting RDF to other EU Member States vary from those from processing material in the UK. In this report, the environmental impacts of RDF export have been assessed using WRATE, a life-cycle assessment (LCA) tool, and compared against the environmental impacts of processing material in the UK. WRATE is employed widely as an 'industry standard' tool in the UK, and has previously been approved for use by consultants and local authorities by the Department for Environment, Food and Rural Affairs (Defra).[7] Whilst WRATE is not a perfect tool, its wide application is such that the analysis in this report can be audited and peer reviewed by other stakeholders, which adds to the transparency of both the assumptions and the results presented both below, and in Appendix A.1.0.

WRATE allows assessment of environmental impacts to be undertaken using a range of indicators. The core focus of the analysis in this study, is upon the GWP (global warming potential) or 'climate change' indicator. Results from a further five 'default' indicators are presented in Appendix A.1.7.

3.1 Selection of Scenarios for Analysis

The life-cycle impact of transporting and treating RDF at an R1 recovery facility has been compared for the following scenarios:

1) Export of RDF to an R1 facility generating electricity only;
2) Export of RDF to a high efficiency R1 facility with good quality combined heat and power (GQCHP);
3) Treatment of residual waste at an R1 facility generating electricity only located in the UK;
4) Treatment of residual waste at a high-efficiency R1 facility with GQCHP located in the UK; and
5) Landfill of residual waste within the UK.

The above scenarios reflect the treatment routes which currently pervade in today's market. We have not sought to model scenarios whereby higher quality waste-derived fuels, i.e. solid recovered fuels (SRF), are produced to a defined specification for processing in cement kilns or in other manufacturing industries. Such analysis would be more relevant to another study which sought to compare the impacts of domestic use of SRF with the export of such material.

We have also not modelled treatment of RDF or residual waste at ATT facilities. In the first allocation round, the results from which were announced in February 2015, a

[7] Eunomia is a registered 'expert user' of WRATE

number of ATT projects received offers from the Department for Energy and Climate Change (DECC) for funding by way of Contracts for Difference (CfD) and therefore may proceed to financial close. However, the environmental impacts from such facilities, particularly those relating to climate change, are very similar to those from 'traditional' (R1) incineration. As a consequence inclusion of additional scenarios to reflect the impacts of ATTs would essentially be duplication.

3.2 LCA System Boundaries

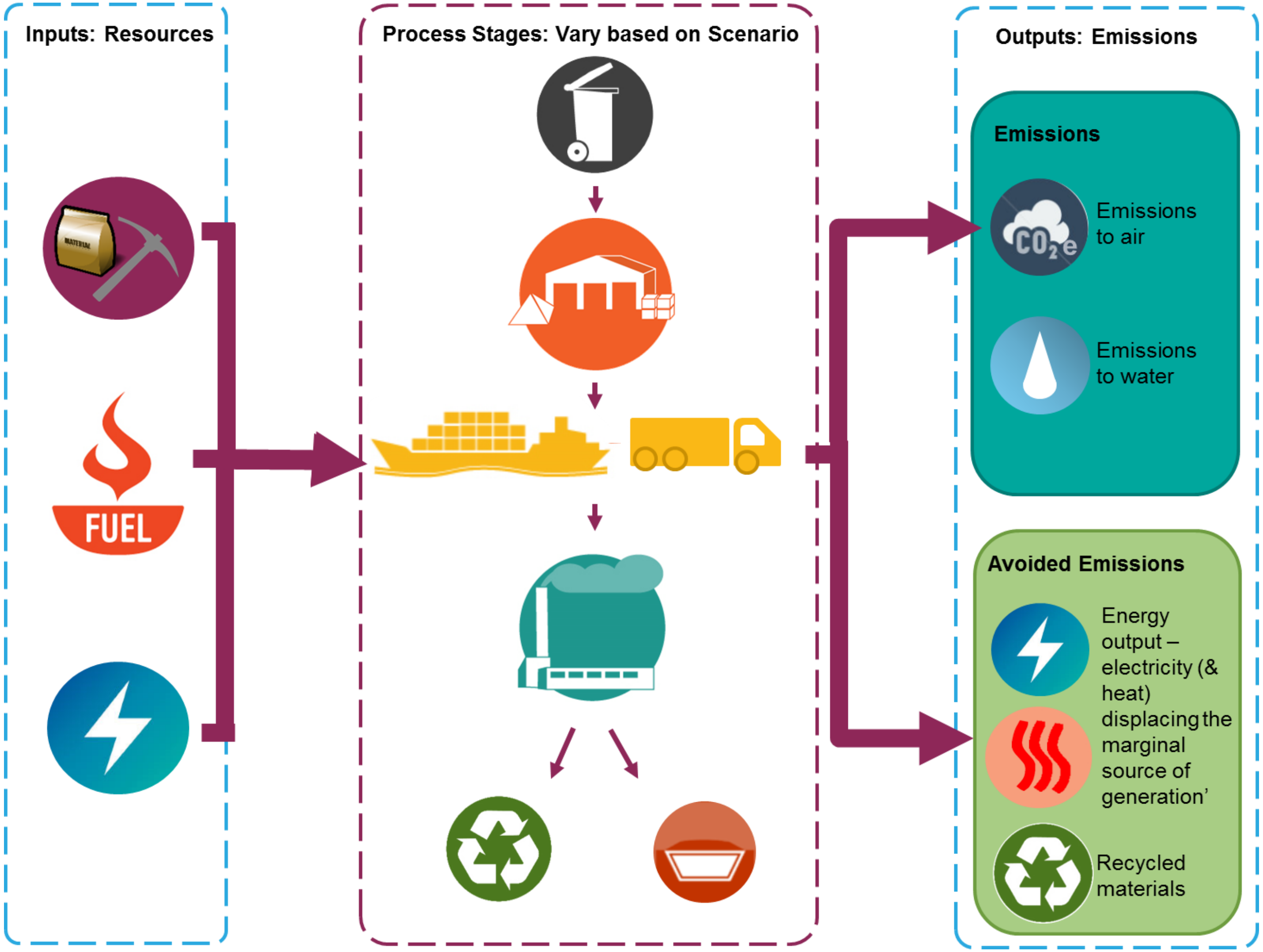
Impacts for each of the five scenarios presented in Section 3.1 are calculated on the basis of 10,000 tonnes of waste being (exported and) treated. The assessment includes the following impacts within what are known, in LCA terms, as the 'system boundaries' of each scenario:

- Emissions associated with the construction, ongoing maintenance and decommissioning of the waste treatment facilities;
- Emissions from the transport of residual waste or RDF by road;
- Emissions from the shipping of RDF where this is exported;
- Direct emissions from waste treatment facilities, including those from both R1 facilities and the RDF 'pre-treatment' plant;
- Impacts associated with the electricity demand at waste treatment facilities and landfills;
- Emissions which are 'avoided' as a result of the recovery of materials from waste treatment, which subsequently replace the use of virgin materials for manufacturing processes;
- Emissions which are avoided as a result of the generation of energy from the biogenic fraction of wastes, which replaces energy generation by alternative means, for example, gas or coal; and
- Impacts from the landfilling of waste, including those associated with the fly ash arising from R1 facilities.

These system boundaries are summarised in Figure 3.1.

To provide full transparency on the WRATE modelling, we have set out the key assumptions used for each of the above impacts in Appendix A.1.1.

Figure 3.1: LCA System Boundaries



3.3 Results from LCA Modelling

Table 3.1 presents the climate change indicator results, showing the net carbon dioxide equivalent (CO_2e) emissions for each scenario. A negative figure represents a net carbon saving (avoided emissions), whilst a positive figure is representative of net carbon impact (additional emissions). Both the UK and export CHP scenarios result in net carbon savings, whilst the two electricity-only scenarios result in more carbon being emitted than is avoided. The far better performance of the CHP scenarios demonstrates the importance, in environmental terms, of using the heat produced by R1 facilities, either in district heating applications or in industry. This is explored further below.

Table 3.1: Net Climate Change Impacts

Scenario	Net Climate Change Impact (kg CO_2e)
Scenario 1: Export electricity only	1,774,093
Scenario 2: Export CHP	-89,883
Scenario 3: UK electricity only	1,512,555
Scenario 4: UK CHP	-351,421
Scenario 5: Landfill	2,462,216

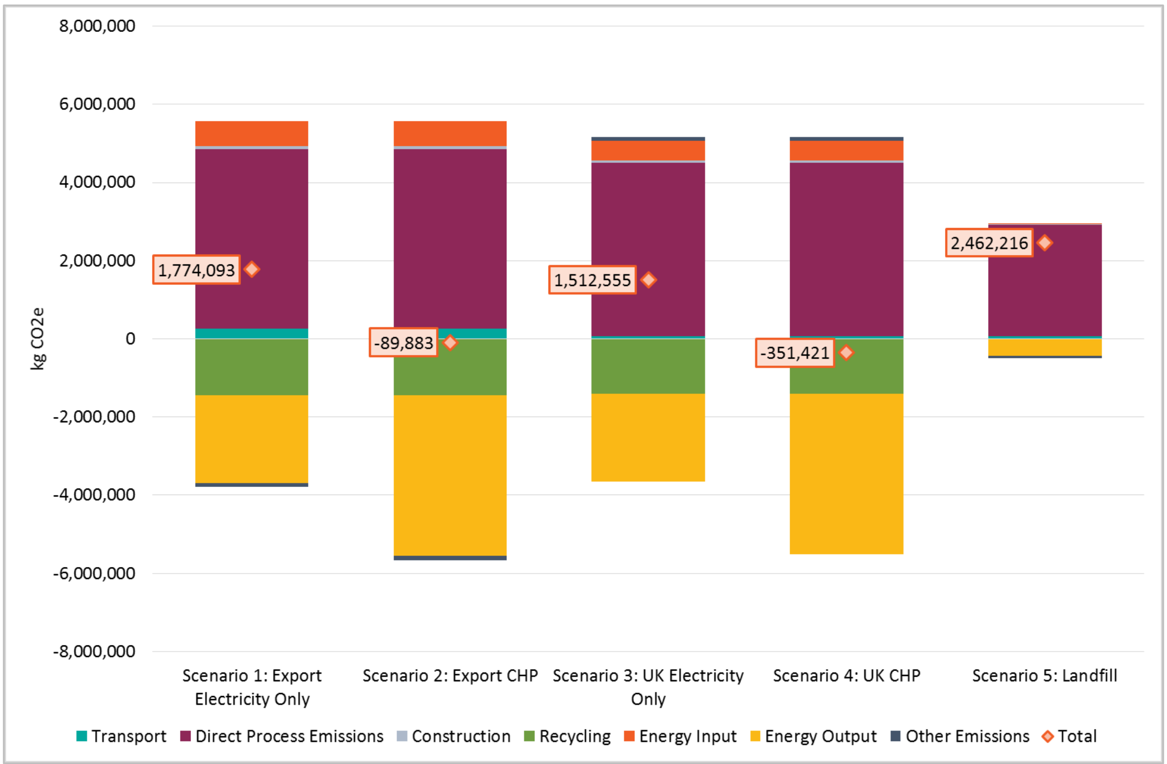
Figure 3.2 shows a more detailed breakdown of the CO_2e emissions associated with each scenario, which are comprised of those from construction, transport, electricity use, direct process emissions and the benefit of avoiding electricity generated by more carbon intense sources ('energy output').

The results presented in Figure 3.2 suggest the following:

- Transport is a very minor contributor to total CO_2e emissions. Whilst the emissions from transport in are four times greater in the export scenarios (than in the UK scenarios), emissions from transport account for just 3% of total emissions. It should also be noted that RDF is often 'back-hauled' which can effectively eradicate transport emissions, as explored in the transport sensitivity analysis in Section 3.4.2;
- Emissions from construction make only a modest contribution to total emissions. These are marginally higher for the two export options as a consequence of the additional impacts associated with the pre-treatment facility which is required to prepare RDF for export;
- 'Other emissions', which include maintenance and decommissioning burdens as well as impacts relating to water use, are similarly relatively minor, and are the same across all scenarios;

- Emissions from the electricity which is used by the incinerator are far larger but again consistent across all scenarios;
- Direct process emissions account are by far the largest contributor to the total, and are again similar across all of the four R1 scenarios;
- Emissions 'Benefits' associated with recycling are marginally greater for export scenarios due to pre-treatment; and
- The emissions avoided through energy generation ('energy output') are far higher under the CHP scenarios than under the electricity only scenarios.[8]

Figure 3.2: Detailed Breakdown of Climate Change Impacts



3.4 Sensitivity Analysis

Appendix A.1.0 provides full transparency with regard to the central assumptions used in the model. However, there are not only a range of uncertainties associated with modelling of this nature, but also a number of variables which depend, for example, on the specific RDF pre-treatment process or upon the infrastructure operating in the destination country for the RDF. We have therefore tested the sensitivity of the results to changes in the following assumptions:

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[8] For all scenarios, we have used the same assumptions to model the benefits of displacing more carbon intense energy. This is discussed in more detail in Appendix A.1.3

- Levels of materials recovery during the pre-treatment of residual waste to produce RDF; and
- Transport distances.

The assumptions used in this modelling, and results from the sensitivity analysis are presented in Sections 3.4.1 and 3.4.2.

3.4.1 Pre-treatment

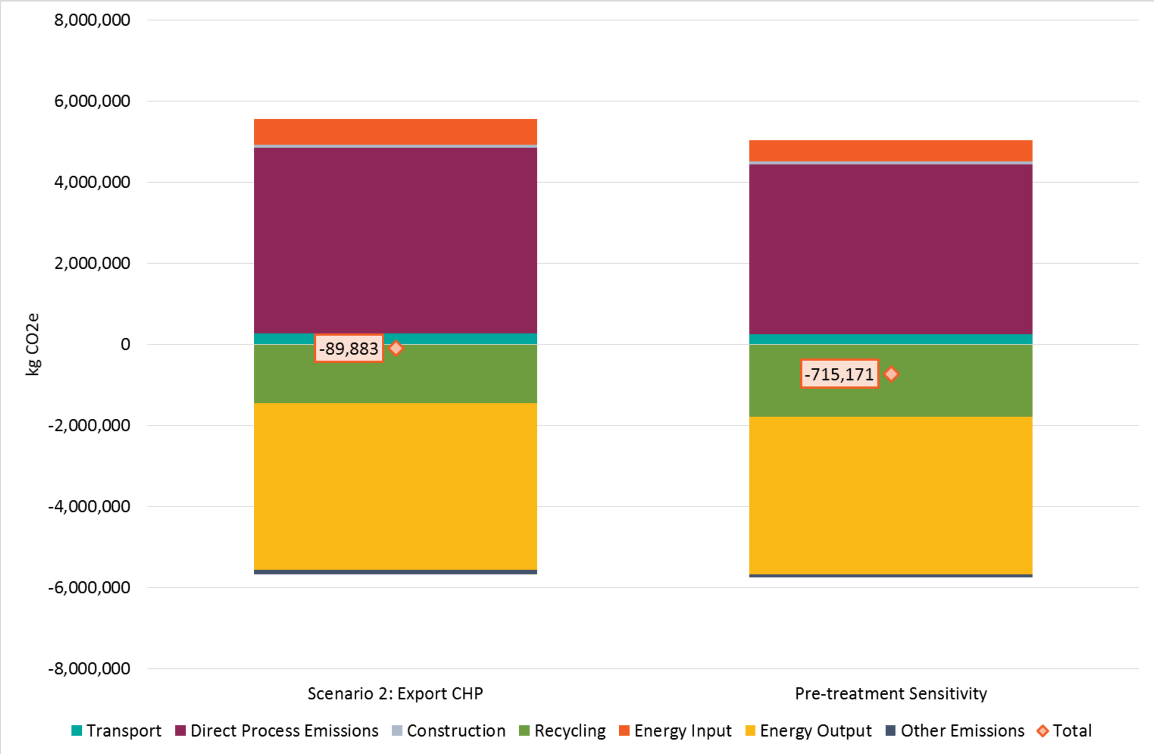
In order to represent the range of approaches to pre-treating RDF currently operating in the market we will have modelled an additional, more sophisticated pre-treatment scenario, with materials recovery rates of:

- 80% ferrous metals;
- 45% non-ferrous metals; and
- 25% rigid plastics.

This can be compared with the recovery of solely 80% of ferrous metals under our central assumptions.

The results of the pre-treatment sensitivity analysis are presented in Figure 3.3. As it is the relative change which is important, for simplicity results are presented solely for one scenario (Scenario 2: Export CHP). This analysis shows that increasing the level of materials recovery during the RDF pre-treatment phase results in a material improvement in the performance of the scenario. It should also be noted that some transfer stations might provide similar levels of materials recovery for waste which is subsequently sent for treatment in the UK.

Figure 3.3: ‘Pre-treatment’ Sensitivity Analysis for Scenario 2



3.4.2 Transport

To test the sensitivity of the results to both longer transport distances and backhauling, we have modelled the impacts of two transport sensitivity scenarios.

- Transport sensitivity 1: shipping distance of RDF is increased to 2,050 km to represent a scenario where RDF is exported to Sweden;
- Transport sensitivity 2: back-haul is assumed for all shipping of RDF.[9]

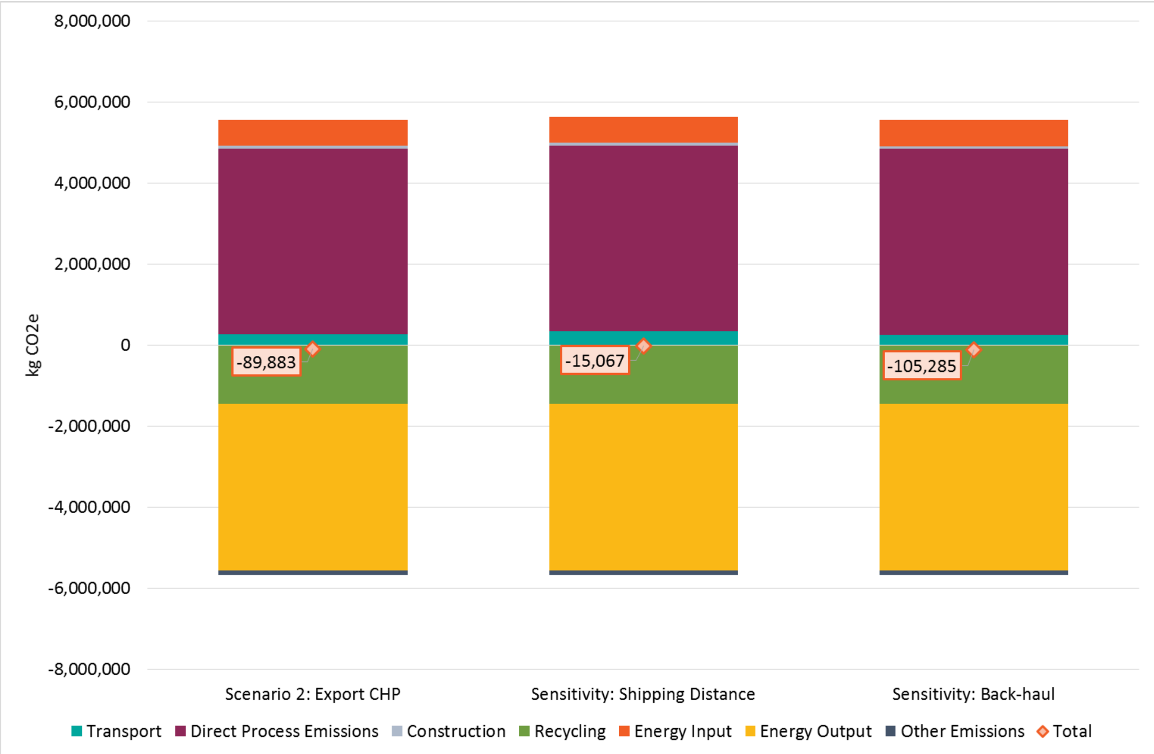
These sensitivities can be compared with a shipping distance of 350 km to the Netherlands under our central assumptions. The road transportation in UK and receiving country remain the same across all scenarios.

The results of this analysis are presented in Figure 3.4. As it is the relative change which is important, for simplicity results are again presented solely for Scenario 2: Export CHP. The most important finding from the analysis is that in the context of total emissions,

[9] Back-hauling is where ships would be travelling empty if not filled with a low value cargo, in this case RDF. It is possible in situations whereby there is a net trade (or shipping freight) imbalance between two geographies, in this case the UK and mainland Europe. The net emissions from moving RDF in this way can therefore be counted as ‘zero’ as they would have happened anyway

those from shipping are very insignificant. Even when the shipping distance is increased by 1,700 miles, total emissions rise by only 1%. At the same time, whilst back-hauling means that there are effectively no emissions from shipping, total emissions fall by less than 1% under this scenario.[10]

Figure 3.4: Transport Sensitivity Analysis for Scenario 2



[10] It should be noted that road transport distances are kept constant under all scenarios. Road transport is far more carbon intense (per km) than shipping

4.0 Combatting Illegal Practices

4.1 Background

This section considers illegal practices specifically in relation to RDF export, and makes recommendations for practical measures to tackle such activities. Defra has recently consulted on waste crime, which included issues relating to RDF export.[11] The RDF Group submitted a formal response to this consultation. Much of the commentary here, therefore, draws upon that response.

Waste crime can cause significant damage, blighting the areas where it occurs, posing a risk to the environment and human health, and affecting the livelihoods of those who work in the legitimate waste management industry.

It is vitally important to distinguish between legitimate waste management and export activities from criminal activities that involve waste. With a number of high profile stories about abandoned waste piling up at UK docksides, transfer stations or in fields there is a danger that the legitimate waste export industry become associated with the negative and criminal activities of a few rogue operators.

There is no link between the legitimate growth of the RDF export industry and cases of waste being abandoned and sometimes ignited. RDF export requires tracking of waste through Trans-Frontier Shipment (TFS) certificates. As such a mechanism is already in place requiring operators exporting waste to comply with the notification controls procedure described in Section 2.1.1. Waste that is located in the UK, and not the subject of TFS certification, is therefore not destined for export. Although cases of abandoned waste are in some instances cited as the malign effect of waste export, they would be better understood, and regulated, as a matter of domestic non-compliance and enforcement.

Sections 4.2.7 to 4.2.5 set out a series of recommendations for tackling illegal activities that harm the reputation of legitimate operators. The motivation for waste crime is often economic, meaning that, whilst an environmental regulator is best placed to deal with potential clean up issues, they may not always be best equipped to investigate economic crime.

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[11] Defra (2015) *Waste crime: consultation on proposals to enhance enforcement powers at regulated facilities; and call for evidence on other measures to tackle waste crime and entrenched poor performance in the waste management industry*, February 2015

4.2 Recommended Measures to Tackle Illegal Activities

4.2.1 Powers to Suspend Permits for Non-compliance

The regulator, supported by industry, must enforce against non-compliant operators using existing powers including suspension notices and stop notices as set out in:

- The Environmental Permitting (England and Wales) Regulations 2010 ('the EP Regulations'); and
- Regulatory Enforcement and Sanctions Act 2008 ('the RES Act').

Whilst existing regulations empower the regulator to use enforcement and sanctioning tools where there is a risk of causing serious harm to human health or the environment, in a large number of cases the motivation for non-compliance is likely to be economic. The regulator should be able to suspend or revoke a permit where an operator fails to meet the requirements of an enforcement notice, irrespective of whether there is a serious risk of pollution.

Furthermore, whatever the motivation, non-compliance can have a major impact on amenity without necessarily causing immediate pollution. Where the situation involves waste potentially being readied for export (e.g. abandoned bales of waste supposedly waiting onward transportation) this is particularly important since if a crime is being committed it is likely to be an 'economic' crime that may have limited immediate impact on the environment, but which nevertheless is a serious case of non-compliance.

4.2.2 Powers to Issue Notices to Avoid Permit Breaches

The regulator must use its powers within the EP Regulations to specify the steps that must be taken to remedy any environmental permit contravention or to ensure that the likely contravention does not occur. Furthermore the regulator should be enabled to issue notices that include steps an operator must take to prevent the breach of a permit getting worse. These extended powers should apply to any site in non-compliance; whether or not the site is otherwise 'poorly managed' (a standard that we recognise is very hard to define).

Where such activity involves the build-up of waste potentially being readied for export then the regulator should be able to prevent such build-up continuing and should be able to require the operator to remove the waste. The Regulatory Position Statement (RPS 128) states that from 30th April 2015 the EA require the storage of waste for export to be permitted and so such waste should be the subject of these extended enforcement powers.

4.2.3 Modification of the Nature of Permits

There are additional changes required in order to prevent the build-up of waste on sites. In many cases we believe that the regulator does not know if 'too much' waste has been deposited at a site as the permit conditions are often deficient. Take the build-up of waste at a Waste Transfer Station, for example. If there is no defined area (and height) within which waste has to be placed (there are no such requirements in Standard Rules

Permits) other than the site boundary, then the regulator may find it difficult to enforce against non-compliance. Similarly, if there is no maximum tonnage limit for how much waste can be stored on a site at any given time, then again the regulator cannot enforce against non-compliance. Again, if there is no permitted limit for how long waste may be stored on the site awaiting transfer, then the regulator again cannot enforce against non-compliance.

All sites permitted to store waste, even incidentally as part of a wider operation such as transfer, should have clearly defined areas (and heights) within which waste must be stored and should have a maximum tonnage limit how much waste can be stored at any given time.

4.2.4 Greater Focus on Non-permitted Sites

Existing enforcement activities can be overly focussed on tackling poor performance of permitted sites. Whilst this is important, the focus should *also* be on harmful illegal activity being undertaken *outside* of the permitting system which would be largely unaffected by the above proposals.

4.2.5 Powers to Physically Intervene

The regulator should have the powers to physically intervene at a site to prevent waste from entering where it is clear such waste is either not permitted at the site (such as at an illegal site) or where too much waste has already been received at the site.

4.2.6 Improved Funding of the Regulator

As well as the powers available to the regulator, Government should strengthen the regulator through increased funding. It is vital that the regulator has adequate resources to execute its function. In ensuring that the regulator has sufficient resources, it should have more ring-fenced money to tackle criminal activity. Landfill tax receipts, and proceeds of crime should both be hypothecated to reinforce and expand EA resources.

4.2.7 Better Management Control of Ownership

Establishing better management control of ownership of waste is essential. Waste operators should have the financial capacity to cover the cost of onward treatment of waste until such treatment is complete. This capacity should be related to the amount of waste that can be legally stored on a site, and based on the risk associated with such storage. In order to protect both human and environmental health – and indeed the reputation of respectable operators – it is logical that Government and Industry should guard against the domestic abandonment of waste.

5.0 Economic Context

This section explores the potential economic impacts of RDF export, and considers the benefits and losses to the UK economy.

Some within the industry have expressed concerns that the export of RDF reduces the availability of RDF on the domestic market, discouraging investment in new waste treatment facilities, resulting in a loss of potentially valuable resource to the domestic economy.

In reality, the economic impacts of RDF export are far more complex than simply looking at potential lost gate fee revenue and associated investment (or lack thereof) in new UK waste treatment infrastructure. The export of RDF impacts on different players, and the economy as a whole, in different ways. As well as potential losses from the UK economy in terms of gate fee revenue, there are additional factors at play, at different stages of the waste management chain.

In Sections 5.1 to 5.3, we consider:

- The key costs and benefits to waste producers;
- The key costs and benefits to waste contractors; and
- The wider economic impacts of RDF export.

A full cost-benefit analysis (CBA) or macro-economic analysis has not been attempted within the scope of this study. Rather the focus is upon qualitative analysis, which is coupled, where available and applicable, with elements of quantitative data to further inform the evidence base.

5.1 Cost and Benefits for Waste Producers

Producers of residual waste pay for its treatment or disposal. Following market principles, unless driven by legislation to do otherwise, waste producers will, where possible, opt for the cheapest treatment or disposal option.

The significant escalation of the Landfill Tax, along with recycling targets for LAC waste and corporate social responsibility (CSR) initiatives within the commercial sector means that disposal to landfill has become a less attractive option for waste producers. Spare treatment capacity, and more efficient CHP plants in other MS are such that overseas treatment facilities are able to offer lower gate fees than domestic facilities.

5.1.1 Current Gate Fee Differentials

Whilst any gate fees available to the RDF Group are commercially confidential, information on 'typical' gate fees for a range of disposal and treatment options (for both LAC and C&I wastes) is publicly available. An example of such information is presented in Table 5.1 for landfill, domestic incineration and exported RDF. This data is intended to give a high-level indication of how different options compare, rather than representing any definitive view on gate fees.

Table 5.1: Current Indicative Gate Fees for June 2015

	£ / tonne low	£/ tonne high
Landfill (including tax at 'Standard' Rate)	93	120
Domestic Incineration	65	100
Baled RDF (includes transport costs but not preparation costs)	67	90
RDF preparation costs	10	15

Source: http://www.letsrecycle.com/prices/efw-landfill-rdf-2/

5.1.2 Future Direction of Travel of Gate Fees

5.1.2.1 Landfill

The main driver for increases in landfill gate fees is the Landfill Tax. This currently stands at £82.60/ tonne at the standard rate, and is set to increase (according to indexation) to £84.40/ tonne from April 2016. Landfill gate fees are therefore relatively stable and predictable, rising in line with landfill tax.

5.1.2.2 Domestic Waste Treatment

As further domestic waste treatment capacity comes online and assuming exports of RDF remain at least constant, gate fees for domestic incineration are likely to become more competitive. On the supply side, the quantity of residual waste is a result of both the total waste arising, i.e. how much waste is produced, and how much of that waste is recycled.

The rate of increase in levels of recycling has declined over recent years and some local authorities have recently reported rises in residual arisings. At the same time, however, the UK has a target to recycle 50% of waste by 2020 and if recycling continues to increase, and therefore residual arisings decrease, in line with legislative drivers, there will be a resulting fall in residual waste requiring treatment. This is likely to lead to more competition for this waste, and thus may lower the cost of UK incinerator gate fees

In December 2014, the European Commission announced the withdrawal of its legislative proposal for the review of waste legislation (the Circular Economy Package), to be replaced by a new, 'more ambitious', initiative for the promotion of the circular economy by the end of 2015. The Commission is currently consulting on its proposals and whilst the content of the action plan will not be known until its publication, it is anticipated that more ambitious recycling targets (over and above the 50% target for 2020) will be set out for future years. This will therefore not only impact upon the potential quantity of residual waste available in the UK, but also upon that available in other MS.

5.1.2.3 Export of RDF from the UK

Gate fees for export of RDF from the UK are similarly affected by growing competition at facilities within the UK, and also from ongoing competition among facilities across a range of MS.

In recent report published by the EA, it is suggested that RDF exports may be 'levelling off' due to export routes becoming as expensive as English landfill. This is to misunderstand both the market dynamics and the data. As the data in Section 1.0 (and further monthly data for 2015) shows, we see no real indication that RDF export is levelling off. Exports are predominantly driven by the amount of spare capacity at R1 facilities in other EU Member States. Whilst operators in other Member States hold spare capacity which needs to be filled by imported RDF, gate fees will continue to be set below English landfill costs to attract waste.

Future direction of travel is also dependent a further range of factors including:

- The tonnage of residual waste arising within other MS. This is influenced by total waste arisings and recycling levels, which are subject to the same EU targets as the UK, as discussed above;
- Gate fees and the supply of residual waste being imported from other MS (in addition to the UK) into Germany, Sweden and the Netherlands;
- The relative price and potential reductions in operating costs provided by the processing of other biomass fuels at CHP facilities in Sweden (and Denmark);
- The potential closure of a limited number of facilities in mainland Europe, particularly in Germany; and
- The £:€ exchange rate.

Typically, it is C&I waste rather than LAC waste which is exported as RDF, albeit local authorities are increasingly seeking to procure RDF export solutions. Local authorities have historically procured longer term treatment or disposal contracts, for up to 25 years, although more commonly today are seeking contracts for 5 to 15 years duration. C&I contracts are usually shorter (typically 1-5 years). This means that gate fees for RDF export are more likely to fluctuate more regularly in line with the factors described above.

5.1.3 Future Outcome for Waste Producers

The above analysis suggests that RDF export has exerted downward pressure on gate fees paid by producers of waste in the UK to UK operators. Whilst at present, this influence has been limited by the fact that supply of residual waste still outstrips demand from operating facilities, the mere presence of the RDF export market has forced most UK operators to at least maintain historic prices. More importantly, however, the presence of the RDF market has also provided a lower cost outlet for both businesses and local authorities that would otherwise need to send residual waste to landfill.[12] The direction of travel of gate fees suggests that these benefits are likely to continue, with gate fees likely to fall in response to lower levels of residual waste being available and growing domestic treatment capacity.

5.2 Costs and Benefits for UK Waste Contractors

The export of RDF represents a loss of income for UK Waste Contractors which would otherwise have received a gate fee for managing waste either by treatment or landfill. This loss of income is in the order of £10-£35 / tonne for landfill operators, and £65-£100 for waste treatment plant operators (based on the publicly available data presented in Section 1.1.1). It should be acknowledged, however, that as mentioned in Section 5.1.3, supply of residual waste currently outstrips demand, and therefore the operators of incineration plant are currently not effectively losing income in this way.

At the same time, however, other waste contractors are generating revenue and running profitable businesses associated with the handling of RDF for export.

There are a number of stages associated with the preparation of waste prior to it being exported as RDF:

- Collection, bulk handling and transfer of residual waste;
- Pre-treatment, including the removals of recyclable materials, shredding and baling; and
- Preparation and administration of TFS notification documentation;
- Bulk transfer to port; and
- Portside handling and wider operations.

Each of the above represents an opportunity for waste contractors and the potential for job creation. As mentioned above, whilst we have not attempted a full CBA as part of this study, it can be surmised that the loss in gate fee income to domestic landfill operators (and in the future domestic incinerator operators) might, to some extent, be offset by revenue generation by other (or the same) operators along the RDF production and supply chain.

5.3 Wider Cost and Benefits for UK Plc

RDF export is effectively an import of services by the UK, which might otherwise have been provided in the UK. The practice, therefore, has a negative effect on the UK's balance of payments. In terms of macro-economic effects, RDF export also impacts upon employment opportunities and environmental taxation. These impacts are explored in Sections 5.3.1 and 5.3.2.

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[12] Downward pressure is exerted where cheaper export option exists, regardless of total supply waste quantities

5.3.1 Employment

The export of RDF reduces the number of employment opportunities associated with the operation and management of waste treatment facilities. The development of new facilities in the UK also provides employment opportunities in design, engineering and construction. Although most of these jobs are of a fixed, short term nature, the export of RDF has a negative impact on such opportunities. Estimates of number of employees required to process waste at incineration plant range from 1 to 5 per 10,000 tonnes, as set out in Appendix A.2.0.

This is far fewer employees compared with other waste treatment methods. As described in Section 5.2, whilst the jobs associated with operating waste treatment plant fall as a result of RDF export, new employment opportunities are created in the processing, transportation and handling of RDF prior to export. Processing facilities have a far higher employment 'intensity' than incineration plant. Estimates of jobs at MRFs range from 10 to 30 per 10,000 tonnes of waste managed, as shown in Appendix A.2.0.

As discussed above, there are also further employment opportunities created in the specialist supply chain of RDF preparation and transfer, including waste collection and transfer, and at portside for the handling of RDF from delivery to loading of cargo vessels. The preparation and transfer of waste is far more labour intensive than the management of waste at incinerators. Furthermore, assuming that export of RDF results in greater levels of capture of recyclable materials in the UK, there may also be job creation in materials reprocessing, some data for which is again presented in Appendix A.2.0.

5.3.2 Taxation Receipts

Whilst incineration is not taxed in the UK, receipts from the UK Landfill Tax are likely to be lower as a result of RDF export. As mentioned above, Landfill Tax currently stands at £82.60/ tonne at the standard rate, and is set to increase to £84.40/ tonne from April 2016. In 2014, 2.6 million tonnes of RDF was exported. If this had been disposed of at UK landfills, at the standard rate, it would have generated £212 million for HMRC.

However, putting this in the context of overall taxation receipts is important. This loss of Landfill Tax is equivalent to 0.5% of 'environmental' taxation receipts generated by HMRC in 2013. Environmental taxes amounted to 2.62% of the United Kingdom's GDP.

It is also important to note that the purpose of the Landfill Tax is to drive waste away from landfill to treatment methods higher up the waste hierarchy. In this instance, landfill tax is therefore being effective in this goal.

In this context it is also worth highlighting the circularity of Government taxation and spending. Whilst tax receipts fall as a result of RDF export, local authority waste services require less funding due to the lower gate fees brought about by the practice, as discussed in Section 5.1.

5.4 Scenario Analysis

Again, whilst we have not attempted to quantify each of the complex flows of income and outgoings in a full CBA, in Figure 1.1 we have presented an overview of the costs and benefits associate with the three following scenarios:

- Scenario 1 – RDF export:
  - Residual waste undergoes pre-treatment in the UK and is sent to R1 facilities in other MS;
- Scenario 2 – Development of domestic waste treatment capacity:
  - New waste treatment capacity is constructed and operated in the UK;
- Scenario 3 – Landfill:
  - Residual waste is sent to landfill.

Figure 5.1: Summary CBA of Approaches to Residual Waste Management

Impact		Export of RDF	Development of Domestic Incineration Plant	Landfill
Cost to producer (gate fee)		✓✓	✓	✗
Direct employment in UK	Construction	✗	✓✓	✗
	Preparation, handling, shipping	✓✓	✗	✗
	Operation	✗	✓	✓
Taxation receipts		✗	✗	✓

6.0 Impact of 'Lost' Energy from RDF Export

Under the EU Renewable Energy Directive (RED), the UK is committed to delivering 15% of its energy from renewable sources by 2020. This section considers the role of domestic EfW in relation to DECC's goal of delivering a secure, low carbon and affordable energy system, and how RDF export impacts upon this goal.

The analysis focuses on:

1) The potential contribution of domestic EfW to *total* UK electricity generation;
2) The potential contribution of domestic EfW to *renewable* electricity generation and targets.

These issues are explored in Sections 6.1 and 6.2.

6.1 Contribution to total UK electricity generation

To calculate the potential contribution that the RDF which is exported might alternatively make to total UK electricity generation we have undertaken high level modelling based on the assumptions set out in Table 6.1.

Table 6.1: Key Assumptions

Key Variable	Assumption
Quantity of residual waste arising in UK suitable for EfW that was sent to landfill in 2014 (million tonnes)	14.7
RDF exported in 2014 (million tonnes)	2.6
Calorific value (CV) of residual waste	9
Average electrical efficiency of UK EfW facilities (%)	25[1]

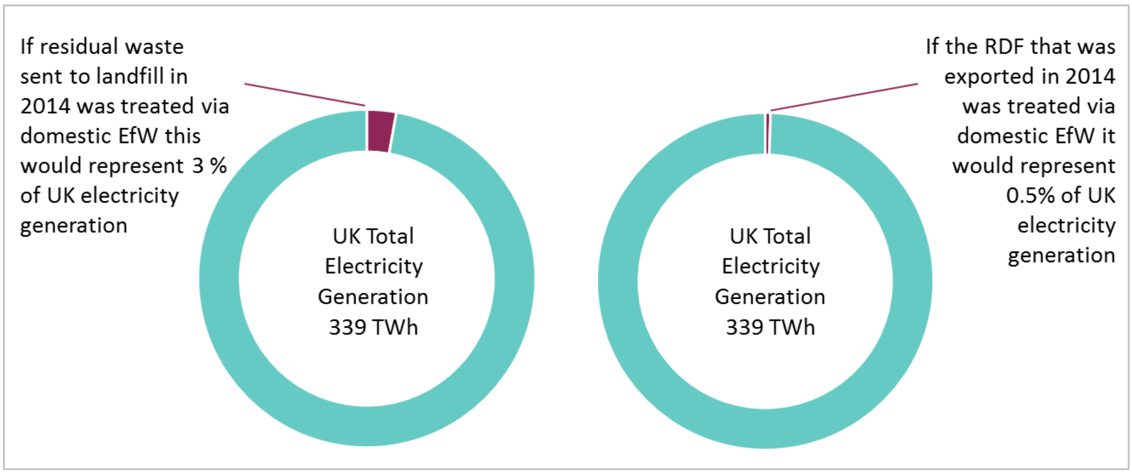
Notes:

1. This represents an optimistic estimate of average efficiency, but is appropriate for modelling of this nature

If the total residual waste that is suitable for treatment and is currently sent to landfill in the UK (14.7 million tonnes) was treated at domestic EfW facilities, it would generate 9,521 GWh of electricity. In 2014, the UK generated 339 TWh of electricity, meaning that the generation of electricity from the entire remaining residual waste would amount to less than 3% of total generation. More importantly, in 2014, 2.6 mt of RDF was exported.

If treated domestically, this would contribute around 0.5% to total UK electricity generation, as presented in Figure 6.1.

Figure 6.1: Contribution to UK Electricity Generation



6.2 Contribution to Renewable Energy Generation and Targets

When considering the contribution that exported RDF could make to renewable energy generation it is important to understand the way in which residual waste is 'counted' as renewable energy. As set out in the RED, only non-fossil sources of energy can be considered to be renewable. Energy generated from residual waste is therefore only partially renewable, with only the biomass fraction counting as a renewable energy source.

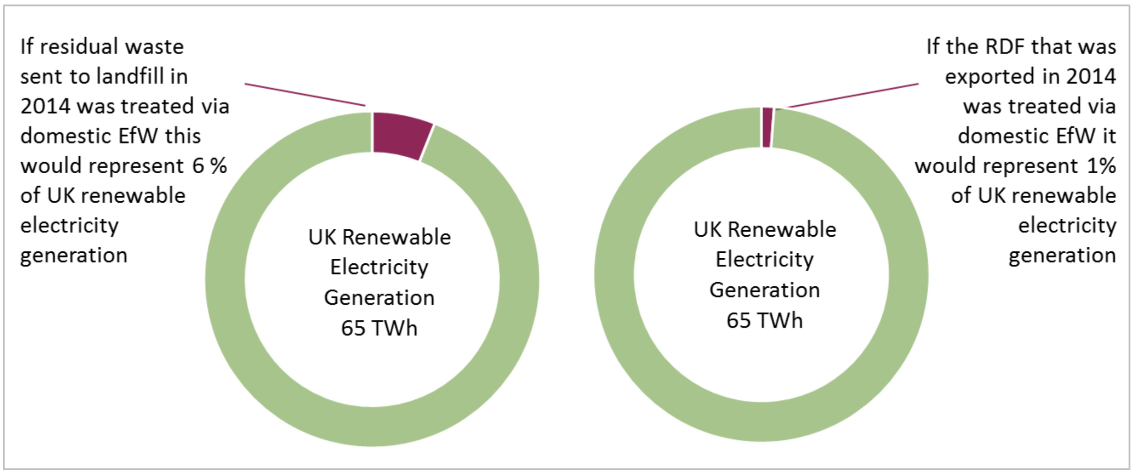
The composition of residual waste is therefore important. Based on the same composition used in the environmental modelling (Section 2.0), the biomass fraction of residual waste represents 58% of the total by weight. However, the CV of 7 GJ/tonne of the biomass fraction, which is largely food waste is lower than that of the fossil carbon based fraction of residual waste. This means that the proportion of residual waste that is renewable, by energy content is actually only around 46%, as set out in Table 6.2.

Table 6.2: Renewable Proportion of Residual Waste

Parameter	Value
CV of residual waste	9
Biomass fraction of residual waste (by weight)	58%
CV of biomass proportion of waste (GJ/tonne)	7
Proportion of biomass by energy content	46%

In 2014, the UK generated 54TWh of renewable electricity. Based on the renewable fraction of residual waste being 46%, as set out in Table 6.2, if the total tonnage of residual waste that is currently sent to landfill was processed domestically, it would account for 6% of renewable electricity generation. More importantly, if the 2.6 mt of RDF that is currently exported was processed domestically it would contribute just 1% to total UK renewable electricity generation, as presented in Figure 6.2.

Figure 6.2: Contribution to UK Renewable Energy Generation



The energy generated from the biomass fraction of waste processed at EfW facilities is supported by renewable energy policy mechanisms, such as the Renewable Obligation (RO), Renewable Heat Incentive (RHI) or Feed-in Tariff (FiT) Contracts for Difference (CfD), if these generate CHP.

For such facilities, unless the operator of the plant undertakes complex and resource intensive fuel measurement and sampling (FMS) procedures in line with Ofgem guidance, under the RO and RHI 50% of the energy generated is ‘deemed’ to be renewable, with this rising to 63.5% under the CfD scheme.[13] In terms of calculating the contribution of EfW to renewable energy targets, again the ‘deemed’ 50% (or 63.5%) is used. Based on this assumption, the 14.7 million tonnes of waste which was sent to landfill in 2014 would account for 9% of renewable electricity generation at the 63.5% deemed level, or 7% at the 50% deemed level. Compared with the 6% we have calculated above, this suggests that DECC’s approach to deeming overestimates the contribution of domestic EfW to renewable energy targets. Furthermore it provides little incentive for operators to provide measured values to Ofgem.

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[13] Ofgem (2014) *Applicant Guidance Note: Fuel Measurement and Sampling Explained*, June 2014 https://www.ofgem.gov.uk/ofgem-publications/82931/applicantguidancenotefuelmeasurementandsamplingexplained.pdf

7.0 Key Messages

The key messages from the evidence presented in the report can be summarised as follows:

- Within existing legislation, there is only limited legal basis for any kind of treatment 'standard' to be introduced for exported RDF and this would be challenging and costly (both to Government and industry) to enforce. The basis for this standard would have to relate to the application of the waste hierarchy, which would need to apply equally to residual waste treated domestically:
    - The Group does not want to discourage operators from recovering more materials from the residual stream. However, a more cost-effective and environmentally preferable approach to enforcing the hierarchy would be for Defra and the EA to focus on regulating and incentivising the greater capture of recyclable materials (including food waste) at source, from both local authority and commercial and industrial (C&I) wastes;
    - Defra and the EA should therefore consider how this might be achieved through better enforcement of the regulations, and work with industry to determine the impacts of such recycling upon residual waste composition, such that this can continue to be effectively treated at both domestic waste treatment facilities and overseas R1 plant;[14]
    - In the context of encouraging recycling at source, an advantage of RDF export is its flexibility. RDF export to overseas facilities has the potential to enable parts of the UK to leapfrog lower levels of the waste hierarchy by providing a flexible treatment route rather than one which often requires long-term guaranteed tonnages of waste. Investment in waste infrastructure in the UK should not be discouraged, rather it is important to focus on the right type and scale of infrastructure that is needed.
- In terms of environmental impacts and benefits, the life-cycle assessment (LCA) of five residual waste management scenarios within this study suggests that:

[14] R1 is an energy efficiency standard which energy from waste (EfW) facilities must meet to be able to legally process RDF from another EU Member States. For further information on the standard, see http://ec.europa.eu/environment/waste/framework/pdf/guidance.pdf

- It is hugely important, in environmental terms, to use the heat generated via recovery of energy from waste, either in district heating applications or in industry, as part of combined heat and power (CHP) configurations;
  - Transport is a very minor contributor to total carbon dioxide (CO_2) emissions. Whilst the emissions from transport are four times greater in the export scenarios (than in the UK scenarios), these still only account for just 3% of total emissions;
  - Even when the shipping distance is increased by 1,700 miles, total emissions for the export scenarios only rise by 1%. At the same time, whilst back-hauling RDF means that there are effectively no emissions from shipping, total emissions fall by less than 1% under such scenarios;
  - Increasing the level of materials recovery during the RDF pre-treatment phase results in a material improvement in the performance of such scenarios;
  - Assumptions relating to the carbon intensity of energy which is 'displaced' by that generated by recovery of energy from waste can have a significant impact upon the results of LCA of this nature; and
  - Ultimately, the relative performance of RDF export scenarios and domestic scenarios depends upon the specific nature of the infrastructure used. The results of this analysis, however, demonstrate that RDF export is currently unlikely to result in any net increase in CO_2 emissions from residual waste treatment.
- There are both costs and benefits in terms of the economic impacts of RDF export. As well as potential losses from the UK economy in terms of gate fee revenue (largely for landfill operators at present), there are additional factors at play, at different stages of the waste management chain for producers, contractors and the wider economy:
  - RDF export has not only increased competition in the market, exerting some downward pressure on gate fees paid by UK producers of waste to UK operators, but has also provided a lower cost outlet for both businesses and local authorities;
  - The loss in gate fee income to domestic landfill (and in the future, waste treatment) operators is to some extent offset by revenue generation by other (or the same) operators along the RDF production and supply chain;
  - Whilst some UK jobs may be lost due to RDF export there are alternative employment opportunities created in waste collection and transfer, and at portside for the handling of RDF from delivery to loading of cargo vessels;
  - Landfill tax receipts fall as a result of RDF export. However, their contribution to overall taxation receipts is minimal. There is also a 'circularity' to this issue as RDF export means that local authority waste services require less funding due to the lower gate fees

available. As a result less central Government funding is required, which to some extent offsets the loss of Landfill Tax revenue.

- Defra's recent consultation on waste crime included issues relating to RDF export and the RDF Group submitted a formal response to this consultation.[15] The RDF Group's consultation response is summarised within this report. In essence, the RDF Group has made a series of recommendations for new measures to tackle illegal activities that are often suggested to be associated with the RDF export market. These include:
    - Powers to suspend permits for non-compliance;
    - Powers to issue notices to avoid permit breaches;
    - Modification of the nature of permits;
    - Greater focus on non-permitted sites;
    - Powers to physically intervene;
    - Improved funding of the Regulator; and
    - Better management control of ownership of waste.
- There is no link between the legitimate growth of the RDF export industry and cases of waste being abandoned and sometimes ignited. RDF export requires tracking of waste through Trans-Frontier Shipment (TFS) certificates. As such a mechanism is already in place requiring operators exporting waste to comply with the notification controls procedure. Waste that is abandoned or ignited in the UK, most of which isn't the subject of TFS certificates, is not destined for export. Although such cases are cited as the malign effect of waste export, they would be better understood, and regulated, as a matter of domestic non-compliance and enforcement;
- If the total residual waste that is suitable for recovery, but which is currently sent to landfill, in the UK (14.7 million tonnes) was treated at domestic R1 facilities, it would amount to both 3% of total generation and 6% of renewable generation (based on our calculations of the renewable fraction of residual waste). More importantly, if the 2.6 million tonnes of RDF exported in 2014 was treated at domestic R1 plant, this would contribute around 0.5% to total UK electricity generation and around 1% to total UK renewable electricity generation.

In conclusion, the evidence presented in this study strongly suggests that the legal framework does not provide for any sensible means of Government intervening to set a restrictive standard for exported RDF. Furthermore, the environmental and economic impacts of RDF export are not wholly dissimilar from domestic treatment of residual

[15] Defra (2015) *Waste crime: consultation on proposals to enhance enforcement powers at regulated facilities; and call for evidence on other measures to tackle waste crime and entrenched poor performance in the waste management industry*, February 2015

waste. Such analysis might be further informed by a more detailed Government Impact Assessment (IA).

APPENDICES

A.1.0 Appendix 1: WRATE Assumptions and Results

A.1.1 Modelling Assumptions

To provide full transparency on the WRATE modelling, in Table A1.1 we have set out our central assumptions relating to:

- Waste composition;
- Transport distances (both ship and road);
- Electrical conversion efficiency of facilities;
- The nature of any useful heat conversion (if any) from R1 facilities;
- Quantity of electricity and fuel use of R1 facilities; and
- The carbon intensity of the baseline electricity mix from which R1 facilities and pre-treatment facilities draw power; and
- The carbon intensity of the 'marginal' sources of electricity and heat generation, i.e. those which are displaced by generation via EfW.

It should be noted that in respect of the assumptions relating to R1 and other waste treatment facilities, we have modelled 'best-of-breed' technologies and performance efficiencies (including those for heat off-take) for both the export and UK-based scenarios.

Table A1.1: High-level Overview of Assumptions for LCA Scenarios

Assumption		Scenario 1: Export Electricity Only	Scenario 2: Export CHP	Scenario 3: UK Electricity Only	Scenario 4: UK CHP	Scenario 5: Landfill
Waste Composition		UK residual waste composition[1]	As for scenario 1	As for scenario 1	As for scenario 1	As for scenario 1
Carbon intensity of energy	**Electricity use (kgCo2e/KWh)[2]**	0.40	0.40	0.46	0.46	0.46
	Marginal source of electricity (kgCo2e/KWh)[3]	0.31	0.31	0.31	0.31	0.31
	Marginal source of heat (kgCo2e/KWh)[3]	0.26	0.26	0.26	0.26	n/a
Pre-treatment of residual waste	**Pre-treatment process**	Metals removal, shred and bale	Metals removal, shred and bale	None	None	None
	Materials recovery rate	80% ferrous metal[4]	80% ferrous[4]	n/a[5]	n/a[5]	n/a[5]
UK road transport	**Transport mode**	Intermodal Road	Intermodal Road	Intermodal Road	Intermodal Road	Intermodal Road
	From – to	Pre-treatment facility to port	Pre-treatment facility to port	Direct delivery and via transfer station to waste treatment facility	Direct delivery and via transfer station to waste treatment facility	Direct delivery and via transfer station to landfill
	Distance (km)	70	70	30	30	30
Shipping	**Method**	Sea container	Sea container	n/a	n/a	n/a
	Distance (km)	350[6]	350[6]	n/a	n/a	n/a
MS road	**Transport mode**	Intermodal Road	Intermodal Road	n/a	n/a	n/a

transport	**From – to**	Port to R1 facility	Port to R1 facility	n/a	n/a	n/a
	Distance (km)	50	50	n/a	n/a	n/a
R1 plant	**Efficiency**	Electricity: 17% Heat: High pressure steam to industry	Electricity only: 28%	Electricity:17% Heat: High pressure steam to industry	Electricity only: 28%	n/a
	Metals recovery	70% ferrous, 30% non-ferrous	70% ferrous, 30% non-ferrous	70% ferrous, 30% non-ferrous	70% ferrous, 30% non-ferrous	n/a
Management of outputs following waste treatment		Metals to recycling IBA to aggregates APC residues to landfill[7]	Metals to recycling IBA to aggregates APC residues to landfill[7]	Metals to recycling IBA to aggregates APC residues to landfill[7]	Metals to recycling IBA to aggregates APC residues to landfill	n/a

Notes:

1. See Appendix A.1.2 for more information
2. This relates to the electricity demand of the treatment facility, as discussed further in Section A.1.3
3. The marginal sources of electricity and heat are those which are 'displaced' by the generation of energy from waste. This is discussed in detail in Appendix A.1.4
4. We have modelled only very basic pre-treatment and materials recovery from residual waste to produce an RDF. In reality, many operators undertake far more extensive recovery of materials to include plastics, paper and wood. We therefore undertook sensitivity analysis on these assumptions as set out in Section 3.4
5. It is assumed that all metals recovery takes place post-treatment
6. This reflects the distance from the Port of Tilbury in the UK to Amsterdam in the Netherlands
7. It should be noted that APC residues can also be used in underground salt mines, or for aggregate. Whilst it is not possible to model these processes within WRATE, the carbon impacts of landfilling APC residues represent <1% of net scenario emissions.

A.1.2 Waste Composition

Table A1.2 presents the waste composition data used in the WRATE analysis. This has been developed from a UK national composition dataset, which has been amended to reflect a recycling rate of 50%, which is representative of a relatively high-performing UK local authority today.[16]

Whilst it is true that the composition of residual waste will change over the time of future contracts for domestic treatment or export, as a result of increasing levels of recycling, we believe that which we have used for this analysis is suitable for the purposes of this study. Furthermore, any changes to composition will have very little impact on the relative performance of the scenarios.

Table A1.2: Waste Composition

Material	Proportion of Waste Stream[1]
Paper and card	11.5%
Plastic film	9.7%
Dense plastic	8.1%
Textiles	4.7%
Absorbent hygiene products including nappies	7.2%
Wood	3.4%
Combustibles	7.4%
Non-combustibles	7.8%
Glass	4.7%
Organic	27.6%
Ferrous metal	5.1%
Non-ferrous metal	0.8%
Fine material <10mm	2.1%

Notes:

1. The composition has been developed to reflect the achievement of a 50% recycling rate by a UK local authority

A.1.3 Modelling of Electricity Use

Electricity use is modelled as the average grid mix ('baseline' mix). CO_2e emissions from electricity demand by waste treatment facilities in the UK are modelled using data

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

published by the DECC for 2015.[17] The carbon intensity of electricity use for the export scenarios is based on the Netherlands' average grid mix.[18]

A.1.4 Modelling of the Marginal Sources of Energy

A.1.4.1 Marginal Source of Electricity

The 'marginal' source(s) of generation is that which is displaced by the generation of energy by recovery facilities. This is a complex and often highly theoretical assumption, which has a significant impact the results from this type of analysis.

There are two main approaches to defining the marginal source(s) of energy:

1. The first approach is to define this as the source of generation that would have been be built if the power from the R1 facility was not available. This is most relevant in situations whereby new generation capacity is needed in a given country; or
2. The second approach is more suited to situations whereby there is a sufficient level of existing capacity and is therefore based upon the existing mix of grid generation.

In the UK, DECC guidance focuses on the former approach and suggests that CCGT should be assumed as the marginal source of generation.[19] Equivalent guidance for Holland, however, due to the greater maturity of the sector, suggests using the latter approach.[20] For Sweden, such guidance does not appear to exist, and the situation is somewhat different in that most waste is generally used as a single fuel type at multi-fuel CHP plant. As a consequence, waste might displace electricity generated by coal or oil or, in rare cases, biomass.

The marginal source of electricity therefore depends not only upon the approach taken, but also upon the type of facility at which waste is processed. It should also be noted that marginal sources of generation change over time. It would therefore be disingenuous to attempt to model different sources for different countries within this study. Within our model we have therefore used the same carbon intensities for the marginal electricity generation across all scenarios.

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[17] Defra / DECC (2014) *Emission Conversion Factors for Greenhouse Gas Reporting*
[18] Defra / DECC (2014) *Emission Conversion Factors for Greenhouse Gas Reporting*
[19] HM Treasury / Department of Energy and Climate Change (2014) *Valuation of Energy Use and Greenhouse Gas (GHG) Emissions*, September 2014
[20] Harmelink Consulting / Agentschap NL / ECN / CBS / PBL (2012) Berekening van de CO_2 Emissies, het Primair Fossiel Energiegebruik en het Rendement van Electriciteit in Nederland

A.1.4.2 Marginal Source of Heat

Within the WRATE modelling heat from the R1 facility in CHP mode is assumed to be high pressure steam used in industrial processes, offsetting an oil and gas mix, with a carbon intensity of 0.26 kg CO2/kWh.

A.1.5 Treatment Facility Assumptions

A.1.5.1 Impacts from Waste Processing

The standard WRATE model for the performance of an incinerator is considerably better than that indicated by the permitted limits for pollutants, for example NOx and SO_2, which fall within the scope the EU Industrial Emissions Directive (IED). These standard assumptions are therefore felt to be representative of performance of a 'best of breed' incinerator treating RDF and so are used in our model.

A.1.5.2 Impacts from Construction, Maintenance and Decommissioning

In WRATE, the standard model for measuring the environmental impacts associated with incineration also includes the impacts associated with construction of the facility, as well as impacts associated with ongoing maintenance and decommissioning burdens and impacts associated with water use. Impacts are reapportioned in WRATE on the basis of the tonnage of waste treated, over the lifetime of the facility. Following this apportionment, impacts do not contribute significantly to the overall results. We therefore propose not to make any changes to the assumptions contained within the standard model in respect of construction, maintenance and decommissioning.

A.1.6 Landfill

We have used the standard WRATE model for landfill as being reasonably representative of landfills operating in the UK. The standard model assumes a landfill gas capture rate of 75%. This is in line with other models of landfill performance in use elsewhere by UK government agencies, such as the model used to calculate emissions from landfill as part of the UK's annual submission to the IPCC. [21]

A.1.7 Results across all LCA Assessment Indicators

WRATE allows assessment of environmental impacts to be undertaken using the following range of indicators:

1) Climate change impacts represented by the 'Global Warming Potential' (GWP), with results expressed in $kgCO_2$ equivalent;

[21] Eunomia / Oonk H (2011) Inventory Improvement Project – UK Landfill Methane Emissions Model, Final Report to Defra and DECC

2) 'Abiotic Resource Depletion', which considers the consumption of resources such as fossil fuels. Results are expressed in kg antimony equivalent;
3) 'Acidification potential', which considers the impact of emissions to air of acidic gases such as NOx and SOx. Results are expressed in kg SO_2 equivalent;
4) 'Eutrophication', which considers the impact of additional nutrients (such as those contained in compost) where these are leached into water bodies, with results expressed in kg PO_4-equivalent;[22]
5) 'Freshwater Aquatic Ecotoxicity', which considers water pollution impacts. Results are expressed in kg 1,4 dichlorobenzene (DCB) equivalent; and
6) 'Human toxicity', which considers the impact of pollution upon human health. As with the Freshwater Ecotoxicity Indicator, results are expressed in kg 1,4 DCB equivalent.

The results for all assessment indicators, for each of the five scenarios under our central assumptions, are presented in Table A1 3.

[22] This indicator is of less relevance where waste is incinerated

Table A1 3: Headline Results – WRATE Default Indicators

Indicator	Metric	Scenario 1: Export Electricity Only	Scenario 2: Export CHP	Scenario 3: UK Electricity Only	Scenario 4: UK CHP	Scenario 5: Landfill
Climate change	kg CO_2 eq.	1,774,093	-89,883	1,512,555	-351,421	2,462,216
Abiotic resource depletion	Kg antimony eq.	509	-2,965	-512	-3,986	1,199
Acidification	kg SO_2 eq.	870	651	695	476	3,139
Eutrophication	kg PO4--eq.	-310,267	-315,469	-328,788	-333,989	12,690
Freshwater aquatic ecotoxicity	kg 1,4-DCB eq.	-3,671,629	-3,777,426	-3,734,767	-3,840,564	-12,128
Human toxicity	kg 1,4-DCB eq.	-26,372	-37,562	-28,611	-39,801	-3,596

A.1.7.1 Full Comparative Results from Sensitivity Analysis

In Table A1.4, we have compared the results from the export Scenarios 1 and 2 with those of the UK-based Scenarios 3 and 4, under both the central assumptions and each of the two areas of sensitivity testing described in Section 3.4. These results demonstrate that:

- All CHP scenarios perform better than the electricity only scenarios;
- Greater materials recovery via RDF pre-treatment results in better performance; and
- Whilst backhauling improves the relative performance of both export scenarios, and greater shipping distances worsens the performance of these scenarios, such transport variables have only a very small impact on the overall results.

Table A1.4: Comparison of Key Sensitivities with UK Scenarios

Scenario		Total Net Emissions (kg CO_2e)[1]
Scenario 1: Export Electricity Only	Central assumptions	1,774,093
	Pre-treatment sensitivity	951,898
	Shipping distance sensitivity	1,848,909
	Back-haul sensitivity	1,758,691
Scenario 2: Export CHP	Central assumptions	-89,883
	Pre-treatment sensitivity	-715,171
	Shipping distance sensitivity	-15,067
	Back-haul sensitivity	-105,285
Scenario 3: UK Electricity Only	Central assumptions	1,512,555
Scenario 4: UK CHP	Central assumptions	-351,421

Notes:

1. In LCA, lower or negative values represent better performance than higher or positive values

A.2.0 Appendix 2: Employment Intensities

Table A2.1: Employment Intensities (FTEs per 10,000 tonnes per annum)

Data Source	Landfill	Incinerator	MRF	Residual Waste Collection	'Reprocessing	Reprocessing: Glass/ Aluminium	Reprocessing: Plastics
SWAP, 1997 (UK)[1]			28		3-67	3-11	67
Murray, 1999 (UK) [2]	≈1	≈1		6	2		
Lepu, 2004 (UK) [3]			18		4-19	4	
Seldman, 2006 (USA) [4]	1	1	10		25	26	93
WRAP, 2012 (UK) [5]							
Eunomia, 2012 (EU) [6]			11				
TBU and Eunomia, 2003 [7]							
University of Glamorgan, 2007 (AU) [8]							
Greenpeace, 2009 [9]		5					
Cottica & Kaurlard, 1995 [10]	≈1	2-4					
DETR/DTI, 1999 (UK) [11]			15-30				
European Commission, 2006 [12]					12		
Various					16	3 –5	70

Notes:

1. Save Waste and Prosper (1999) Employment in the UK Recycling Industry, National Recycling Forum
2. Murray, R. (1999) *Creating Wealth From Waste*, DEMOS, www.demos.co.uk/files/Creatingwealthfromwaste.pdf
3. Gray, A., Jones, A., and Percy, S. (2004) *Jobs from Recycling: Report on Stage II of the Research, Report for Local Economic Policy Unit (Lepu)*, August 2004, http://warrr.org/446/1/Jobs_from_recycling__-__Report.pdf
4. Seldman, N. (2006*) Recycling Means Business. PhD Institute for Local Reliance, Waste to Wealth Program*, www.ilsr.org/recycling/recyclingmeansbusiness.html
5. Urban Mines and Walker Resource Management (2012) *A Survey of the UK Organics Recycling Industry in 2010*, Report for WRAP, www.organics-recycling.org.uk/uploads/article2439/ASORI%20Final%20Report%202010.pdf
6. Eunomia's micro study on employment conducted as part of the European Reference Model on Municipal Waste Management, www.wastemodel.eu
7. TBU and Eunomia (2003) *Cool Waste Management, Report for Greenpeace*, www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/5574.pdf
8. University of Glamorgan (2007) Kahlenberg (ZAK) *MBT Plant*, www.walesadcentre.org.uk/Controls/Document/Docs/Kahlenberg_Comp__F.pdf
9. Greenpeace (2009) *Incineracion de Residuos: Malos Humos para el Clima,* November 2009, www.greenpeace.org/espana/Global/espana/report/costas/091124-02.pdf
10. Cottica & Kaurlard (1995) *The Costs, Environmental Benefits, and Direct Employment Implication of Greening Municipal Waste Management in Europe: An Engineering Estimation, NOMISA, Bologna*
11. Cited in Waste Watch, (1999) *Jobs from Waste: Employment Opportunities in Recycling*, http://wasteonline.brix.fatbeehive.com/resources/WasteWatch/JobsFromWaste.htm
12. European Commission (2006) *Report from the Commission to the Council and the European Parliament on the Implementation of Directive 94/62/EC on Packaging and Packaging Waste and its Impact on the Environment as well as on the functioning of the Internal Market*, www.europen.be/download_protected_file.php?file=109