FICHTNER

MERCIA WASTE

ENVIRECOVER FACILITY

APPENDICES TO PROOF OF EVIDENCE

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PROOF OF EVIDENCE OF STEPHEN OTHEN APPENDICES

Public Inquiry Under Section 77 of the Town and County Planning Act 1990 (as amended)

Application by Mercia Waste Managemnt Ltd for the proposed development of an energy from waste facility on land at Hartlebury Trading Estate, Hartlebury, Worcestershire.

PINS reference: APP/E/1855/11/2153273

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Table of Contents

Appendix A - R1 Calculation

A.1 As explained in my proof of evidence, the R1 Formula is $\frac{E_p - (E_f + E_i)}{0.97 \times (E_w + E_f)}$. Each term in this equation is considered below, with reference to the Commission Guidelines.

Ep

A.2 E_p is defined in Annex II of the rWFD as "annual energy produced as heat or electricity. It is calculated with energy in the form of electricity being multiplied by 2.6 and heat produced for commercial use multiplied by 1.1". The Commission Guidelines make it clear that, in terms of electricity, E_p relates to electricity generated, rather than exported. This is explained in section 3.2.1 of the Guidelines, where it is stated:

> *"E_p thus includes the energy (heat and electricity) recovered from waste which is exported outside the R1 system boundary to third parties or to other uses within the installation, as well as the energy which is used inside the R1 system boundary, e.g. for heating up the flue gas before the chimney, but not including energy uses influencing the steam/heat production."*

A.3 For heat, the Guidelines state "To be counted in E_p, a commercial use needs to be given for heat." E_p also includes "the energy which is used inside the R1 system boundary, e.g. for heating up the flue gas before the chimney, but not including energy uses influencing the steam/heat production" For example, steam used to preheat air is not included in E_p, as this heat is subsequently recovered in the boiler and used to generate steam again.

A.4 If steam is supplied to a heat user and condensate is returned to the Envirecover Facility, the energy contained within the condensate should be subtracted from E_p.

E_f

A.5 E_f is defined in Annex II of the rWFD as "annual energy input to the system from fuels contributing to the production of steam." Fuels do not include wastes. For the Envirecover Facility, the only fuel use is gasoil during start-up and shutdown of the plant while steam is being generated, or when the burners are used to maintain the combustion chamber temperature at more than 850 °C.

E_w

A.6 E_w is defined in Annex II of the rWFD as the "annual energy contained in the treated waste calculated using the net calorific value of the waste." This is a clear definition. The Guidelines for E_w mainly focus on how this is measured, which is not a concern when the R1 efficiency is calculated for the design case.

Ei

A.7 E_i is defined in Annex II of the rWFD as "annual energy imported excluding E_w and E_f." In other words, it covers all energy inputs which are not covered by the energy in the waste and energy in fuels contributing to the production of steam. In the context of the Envirecover Facility, E_i includes any electricity imported when the plant is not running as well as fuel used to heat up the plant before steam is generated.

Calculation of R1

A.8 The calculation of the R1 efficiency is set out overleaf.

R1 calculation

Calculation of Ew

		Power Only	Heat
Waste Throughput	tonnes	200,000	200,000
Waste NCV	MJ/kg	8.3	8.3
Ew	**GJ p.a.**	**1,660,000**	**1,660,000**

Calculation of Ep

		Power Only	Heat
Electricity generated	MWe	15.5	15.1
Operating Hours	hrs p.a.	7,796	7,796
Electricity generated	MWh p.a.	120,844	117,804
	GJ p.a.	435,039	424,093

		Power Only	Heat
Heat Exported	MWth	0	1.3
Heat Exported	MWh	0.00	10,135.32
Heat Exported	GJ p.a.	0	36,487

		Power Only	Heat
Electricity Factor		2.6	2.6
Heat Factor		1.1	1.1
Ep	**GJ p.a.**	**1,131,102**	**1,142,778**

Calculation of Ef

		Power Only	Heat
Burner size	MWth	35.49	35.49
Start ups per year		5	5
Duration of start-up	hrs	16	16
Total energy input from burners	GJ p.a.	10,220	10,220
Fraction of fuel used to generate steam		50.00%	50.00%
Ef	**GJ p.a.**	**5,110**	**5,110**

Calculation of Ei

		Power Only	Heat
Electricity consumption when offline	MWe	0.5	0.5
Hours offline	hrs p.a.	964	964
Electricity imported	MWh p.a.	481.8	481.8
	GJ p.a.	1734.48	1734.48
Fuel used to heat up plant	GJ p.a.	5,110	5,110
Ei	**GJ p.a.**	**6,845**	**6,845**

Calculation of R1 Formula

		Power Only	Heat
R1 Formula result		**0.693**	**0.700**

		Power Only	Heat
Electrical Efficiency		26.21%	25.55%
Heat Efficiency		0.00%	2.20%

A.9 It can be seen that the R1 efficiency is calculated as 0.693, based on power generation alone. This is higher than the threshold value of 0.65.

A.10 The second column shows the R1 efficiency if heat is exported to the Wienerberger brickworks, as discussed in Appendix D. It can be seen that the R1 efficiency increases slightly, to 0.700.

Appendix B - WRATE Report

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MERCIA WASTE MANAGEMENT

HEREFORD AND WORCESTER

RESIDUAL WASTE TREATMENT OPTIONS APPRAISAL

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MERCIA WASTE MANAGEMENT
HEREFORD AND WORCESTER
RESIDUAL WASTE TREATMENT OPTIONS APPRAISAL

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Management Summary

The Herefordshire and Worcestershire Waste PFI was signed in 1998 on the basis of a single large Energy from Waste (EfW) facility at Kidderminster provided by Mercia Waste Management (Mercia). The application for the Kidderminster EfW failed and both the Authorities and Mercia were forced to review the delivered strategy.

In 2009, the Authorities undertook a first review of the Joint Municipal Waste Management Strategy. Annex D of this review consisted of a comprehensive assessment of potential residual waste treatment options. The results of this assessment were that a single site CHP EfW was ranked the highest, followed by a single site Autoclave and a single site power only EfW.

In order to test Mercia's proposed EnviRecover facility against alternative waste treatment strategies, Mercia engaged Fichtner Consulting Engineers Limited (Fichtner) to conduct a similar Options Appraisal in 2010. Mercia have now asked Fichtner to update the Options Appraisal to take account of software changes since the original report was issued.

This options appraisal considers nine different residual waste treatment options:

(1) Option 1 – 1 site power only EfW;

(2) Option 2 – 1 site Combined Heat and Power (CHP) EfW;

(3) Option 3 – Out of county EfW;

(4) Option 4 – 1 site Autoclave with the fibre recycled as fibreboard;

(5) Option 5 – 1 site Autoclave with the fibre landfilled;

(6) Option 6 – 2 site Autoclave with the fibre recycled as fibreboard;

(7) Option 7 – 2 site Mechanical Biological Treatment (MBT) with on-site combustion of the Refuse Derived Fuel (RDF);

(8) Option 8 – 2 site MBT with out of county combustion of the RDF; and

(9) Option 9 – Out of county EfW with segregated food waste treated by Anaerobic Digestion (AD).

These options were scored against fifteen different assessment criteria based on the thirteen criteria considered within the Authorities' assessment. The scoring methodology for these criteria is different from that considered within the Authorities' assessment. Instead of ranking the options, scores are provided based on the options performance against the criteria. The scores from each assessment criteria are combined into a single score based on a weighting. This has been developed based on the reliability of the outputs and also the criteria which are viewed as key by the Authority. A sensitivity has also been performed on Option 8 to examine the impact of an increase in the net electrical efficiency of the out of county EfW on the overall assessment score.

The environmental impacts have been considered using lifecycle assessment software. Bespoke processes were developed in order to accurately model the proposed Mercia EnviRecover facility and a food waste AD facility. Default processes were used for the other technologies considered. Use of the default processes can lead to errors in the reported data. This is particularly the case for the autoclave process, where there are concerns over mass loss and significant scaling.

Option 2 (Mercia EnviRecover facility with CHP) scores the highest overall. This option achieves the highest score in nine of the fifteen assessment criteria. The power only Mercia EnviRecover facility (Option 1) was ranked second, with only a 14 point gap between first and second. There is a clear gap in scores to the third place option, the single site autoclave with fibre recycling, which finishes 38 points lower than Option 1. If the fibre is landfilled (Option 5), which is the more likely position given the lack of a proven market for the fibre, then the overall score is reduced by an additional 27 points. The MBT options are ranked 6th and 7th for the on-site and off-site combustion respectively. The out of county solution is ranked last due to the significant environmental and transport impact as well as significant operating costs. The out of county option with added food AD tied for last. While it showed improved performance in operating costs and transport compared to the out of county EfW option, it received lower scores in abiotic resource depletion, planning risk and waste composition flexibility.

Table of Contents

1 INTRODUCTION

1.1 Background

The Herefordshire and Worcestershire Waste PFI was signed in 1998 on the basis of a single large residual waste treatment facility at Kidderminster. This facility would be based on conventional Energy from Waste (EfW) technology to be delivered by Mercia Waste Management (Mercia).

The application for the Kidderminster EfW failed and both the Authorities and Mercia were forced to review the delivered strategy.

In 2009, the Authorities undertook a first review of the Joint Municipal Waste Management Strategy (JMWMS). Annex D of this review consisted of a comprehensive assessment of potential residual waste treatment options.

Initially a long list of different residual waste treatment options was developed. This was reviewed and a short list of seven different strategies was agreed. These seven options were:

(1) Option A – 1 site Power only EfW;

(2) Option B – 1 site Combined Heat and Power (CHP) EfW;

(3) Option C – 2 site Mechanical Biological Treatment (MBT) with on-site combustion of the Refuse Derived Fuel (RDF);

(4) Option D – 2 site MBT with off-site combustion of the RDF;

(5) Option E – 1 site autoclave;

(6) Option F – 2 site autoclave; and

(7) Option G – Out of county EfW.

Each option was assessed against a range of environmental, economic, risk and social criteria:

(1) Environmental Criteria
- a) Resource Depletion
- b) Air Acidification
- c) Greenhouse Gas Emissions
- d) Freshwater aquatic ecotoxicity
- e) Eutrophication

(2) Financial and Risk Criteria
- a) Financial Costs
- b) Reliability of Delivery
- c) Planning Risk
- d) Compliance with Policy
- e) Flexibility
- f) End Product Liability

(3) Social Criteria
- a) Transport
- b) Health

The results of this assessment were that Option B (1 site CHP EfW) was ranked the highest, followed by Option E (1 site Autoclave) and Option A (1 site EfW).

In order to test Mercia's proposed EnviRecover facility against alternative waste treatment strategies, Mercia engaged Fichtner Consulting Engineers Limited (Fichtner) to conduct a similar Options Appraisal in 2010, using the Environment Agency's WRATE software to quantify the environmental criteria.

Since 2010, a new version of WRATE has been issued. Therefore, Mercia has engaged Fichtner to repeat the Options Appraisal using the new version of WRATE.

1.2 Objectives

To conduct a residual waste treatment options appraisal, utilising:

- a similar range of treatment options as the Authorities' JMWMS first review;
- the proposed Mercia EnviRecover facility within the assessment; and
- a similar range of assessment criteria.

2 Conclusions

(1) The Mercia EnviRecover facility with CHP scored the highest based on the assessment criteria and assumptions used.

(2) The power only Mercia EnviRecover facility scored second highest , only 5% behind the CHP option.

(3) Although the single Autoclave with fibre recycling scored third highest, there are significant questions regarding the availability of a market for fibre recycling and concerns over the WRATE default process and the overall scores were 7% less than the EfW option.

(4) Sending the autoclave fibre to landfill reduces the overall score by 21 points (7%).

(5) MBT based options scored well in a number of categories such as references and BMW diversion, but scored significantly lower (c. 24%) than the Mercia EnviRecover facility options.

(6) The MBT option with RDF sent to the Runcorn EfW scored last due to low scores in end product liability, operating costs, global warming potential and planning risk.

(7) The out of county EfW option scored highest in terms of planning risk and capital cost, but obtained the lowest scores for environmental impact, transportation impact and operating costs and was ranked 7th.

(8) The out of county EfW option with added food AD obtained higher scores than the option without AD for operating costs and transport, but received lower scores for abiotic resource depletion, waste composition flexibility and planning risk and was ranked 7th along with the EfW only option.

3 Recommendations

It is recommended that heat export options be further investigated for the proposed Mercia EnviRecover facility, given that the CHP option scores more highly than the power-only option, but it is clear that the electricity-only option scores significantly higher than any other option.

4 METHODOLOGY

4.1 Options considered

This assessment considers a total of nine different options. These have been developed based on the seven options considered by the Authorities within their options appraisal. The eight options considered are:

(1) Option 1 – 1 site EfW (Power only);
(2) Option 2 – 1 site EfW (Combined Heat and Power);
(3) Option 3 – Out of county EfW;
(4) Option 4 – 1 site Autoclave with the fibre recycled as fibreboard;
(5) Option 5 – 1 site Autoclave with the fibre landfilled;
(6) Option 6 – 2 site Autoclave with the fibre recycled as fibreboard;
(7) Option 7 – 2 site Mechanical Biological Treatment (MBT) with on-site combustion of the Refuse Derived Fuel (RDF); and
(8) Option 8 – 2 site MBT with out of county combustion of the RDF; and
(9) Option 9 – Out of county EfW with segregated food waste treated by Anaerobic Digestion (AD).

Option 6 has been added due to concerns over the marketability of fibre from autoclaves. This additional option allows the impact of simply landfilling the fibre to be assessed.

Option 9 has been added in response to comments from the local campaign group, WAIL, that anaerobic digestion of separately collected food waste should be considered.

A sensitivity was also run on Option 8. This was to assess the impact of an increase in the net electrical efficiency of the out of county EfW on the overall results of the assessment.

4.2 Assessment criteria

This assessment considers a total of 15 different criteria. These have been developed based on the 13 criteria considered by the Authorities within their options appraisal.

(1) Environmental criteria
    a) Abiotic resource depletion
    b) Global warming potential
    c) Human toxicity
    d) Freshwater aquatic ecotoxicity
    e) Acidification
    f) Eutrophication
(2) Financial criteria
    a) Capital cost
    b) Operating cost
(3) Risk criteria
    a) Reference facilities
    b) Planning risk
    c) BMW diversion from landfill
    d) Waste composition flexibility
    e) Waste tonnage flexibility
    f) End product liability
(4) Social criteria
    a) Transport

The key differences in comparison with the Authorities' assessment are:

- "Health" has been re-titled and moved into the environmental criteria;
- The financial criteria have been split into "Capital cost" and "Operating cost";
- "Reliability of Delivery" has been replaced with "Reference facilities" as these are essentially the same;
- "Compliance with Policy" has been replaced with "BMW diversion from landfill", since this is the critical policy issue; and
- "Flexibility" has been split into flexibility to changes in waste composition and waste tonnage as per the Authorities' assessment.

The six environmental assessment criteria have been assessed using the Environment Agency's (EA's) lifecycle assessment software developed specifically for the waste industry. This software is called Waste and Resources Assessment Tool for the Environment (WRATE). The model has been updated to version 2 of the WRATE software which was released in 2010, after the original report was issued. The assumptions for the WRATE model are provided within section 4.4.1.

In order to assess the financial and risk criteria mass and energy balances for each option are required. These balances have been based on the mass and energy balances used within the WRATE model and are summarised within section 4.4.1.14.

The financial criteria have been assessed based on assumptions regarding typical costs and revenues. These are summarised within section 4.4.3. Capital costs have been estimated based on Fichtner's experience of similar projects.

4.2.1 Environmental criteria

Six criteria have been considered.

- There are a finite amount of these resources available in the world that will be eventually used up if current rates of consumption continue. The **abiotic resource depletion** criterion therefore considers the amount of non-living resources used or offset by the various options.
- Greenhouse gas emissions cause heat radiation to be reflected and retained within the atmosphere rather than being lost into space. This effect is known as global warming. Carbon dioxide is the main contributor to global warming, however, other gases such as methane can have an effect. The **global warming potential** criterion therefore considers the amount of contributing gases released or offset by the various options.
- Persistent toxic substances can slowly accumulate in living organisms, increasing the risk that toxic concentrations will be reached. The **human toxicity** criterion therefore considers the amount of substances potentially toxic to humans released or offset by the various options.
- Toxic effects on ecosystems can be either chronic (causing prolonged illness) or acute (short term / immediate effects). The **freshwater aquatic ecotoxicity** criterion therefore considers the amount of substances potentially toxic to ecosystems released or offset by the various options.
- Emissions to air, water and land of acidifying compounds such as sulphur dioxide (SO_2) and nitrogen oxides (NO_x) can contribute to the destruction of plants and acidify the soil, which can result in changes to ecosystems. The **acidification** criterion therefore considers the amount of acid based substances released or offset by the various options.
- Emission of nitrogenous compounds, especially ammonia (NH_3), nitrogen oxides (NO_x) and phosphates, can stimulate increased growth due to a fertilisation effect, leading to altered species in nutrient-poor ecosystems. The **eutrophication** criterion therefore considers the amount of nitrogenous compounds released or offset by the various options.

The Authorities' assessment considered the environmental impacts and scored the options based on their ranking. This methodology does not however consider the spread of the results for each environmental impact.

This assessment therefore scores each of the options based on the deviation from the mean result.

Table 1 – Environmental criteria scoring	
Deviation from mean	**Score**
-109% to -90% from mean	10
-89% to -70% from mean	9
-69% to -50% from mean	8
-49% to -30% from mean	7
-29% to -10% from mean	6
-9% to +9% from mean	5
+10% to +29% from mean	4
+30% to +49% from mean	3
+50% to +69% from mean	2
+70% to +89% from mean	1
+90% to +109% from mean	0

4.2.2 Financial criteria

The Authorities' assessment considered the financial implications as a single assessment criterion based on discounted cash flow techniques. This assessment, however, considers the capital and operating costs separately and therefore enables a simple estimate of the typical annual operating cost and total capital investment to be made.

The capital cost for each option has been estimated based on Fichtner's experience of similar projects at all project stages (tendering, construction and final project costs).

Typical annual operating costs have been estimated based on WRATE's mass and energy balance for each option combined with typical unit operating costs/revenues. These unit costs are based on Fichtner's experience.

Heat exported is assumed to qualify under the Renewable Heat Incentive (RHI). This has been considered within the financial implications based on Fichtner's interpretation of the draft regulations.

The Authorities' assessment ranked the costs and scored the options based on this ranking. This method does not take into account the spread of the costs, therefore this assessment scores the options based on the deviation from the mean cost.

Table 2 – Financial criteria scoring	
Deviation from mean	**Score**
-109% to -90% from mean	10
-89% to -70% from mean	9
-69% to -50% from mean	8

Table 2 – Financial criteria scoring	
Deviation from mean	**Score**
-49% to -30% from mean	7
-29% to -10% from mean	6
-9% to +9% from mean	5
+10% to +29% from mean	4
+30% to +49% from mean	3
+50% to +69% from mean	2
+70% to +89% from mean	1
+90% to +109% from mean	0

4.2.3 Reference facilities

This criterion has replaced the Reliability of Delivery category. The number, location and type of reference facilities are key to understanding the deliverability of a solution. For example, a technology that has multiple UK references is potentially more deliverable than a technology that has a single reference outside Europe. This is considered to be the case as the technology has already demonstrated compliance with UK legislation and the ability to gain funding from Lenders.

Table 3 – Reference facility criteria scoring	
Category	**Score**
Multiple similar scale UK references	10
Multiple UK references	9
Single UK reference, multiple European references	8
No UK reference, multiple similar scale European references	7
No UK reference, multiple European references	6
No UK reference, single European reference or multiple references outside of Europe	5
Single reference outside of Europe	4
	3
Reference(s) under construction or operational for less than 1 year	2
Pilot plant only	1
No references	0

4.2.4 Planning risk

One of the most significant risks to a waste facility project is planning. The options have therefore been assessed based on the perceived risk associated with obtaining planning permission. These have been considered qualitatively by planning consultants Axis. Scores were attributed based on perceived planning risk and experience of projects receiving planning permission.

It should be noted that within the Authorities' assessment, the autoclave options scored well due to an existing planning permission on the proposed site. This has subsequently lapsed and so has not been considered within this assessment. All options are therefore considered based on submitting a new planning application.

4.2.5 BMW diversion from landfill

This assessment criterion has replaced the Compliance with Policy criterion. Within the Authorities' assessment this criterion assessed how closely the option matched the JMWMS. The tonnage of outputs from each option was weighted based on their location within the waste hierarchy. This methodology was considered to be highly dependent on the weightings applied. For example, landfill was only given one point worse than the diversion from landfill with no energy recovery, despite the fact that most UK waste policy is focussed on avoiding landfill.

This options appraisal could suggest alternate weightings, but the values would still be open to debate. Instead this assessment considers the diversion of BMW from landfill and scores the options based on their respective performance as outlined below.

Table 4 – BMW diversion from landfill criteria scoring

Category	Score
95% – 100% diversion	10
90% – 94.9% diversion	9
85% – 89.9% diversion	8
80% – 84.9% diversion	7
75% – 79.9% diversion	6
70% – 74.9% diversion	5
65% – 69.9% diversion	4
60% – 64.9% diversion	3
55% – 59.9% diversion	2
50% – 54.9% diversion	1
<50% diversion	0

4.2.6 Waste composition flexibility

Although the Authorities' assessment stated a single "Flexibility" criterion, the assessment actually considered two sub categories; flexibility to tonnage change and flexibility to composition change. This approach has also been repeated within this assessment.

The options have been assessed based on their ability to accommodate changes in waste composition. These changes could arise due to seasonal variation or due to changes in kerbside collections.

The flexibility to changes in composition and the effect such changes could have on the facility's performance has been considered based on the scoring outlined below.

Table 5 – Composition flexibility criteria scoring

Category	Score
Able to accept wide changes in composition, no performance reduction	10
Able to accept wide changes in composition, minor performance reduction	9
Able to accept small changes in composition, no performance reduction	8
Able to accept wide changes in composition, significant performance reduction	7
Able to accept small changes in composition, minor performance reduction	6
Able to accept small changes in composition, significant performance reduction	5
Strict input requirements, minor performance reduction	4
Strict input requirements, significant performance reduction	3
Very strict input requirements, minor performance reduction	2
Very strict input requirements, significant performance reduction	1
	0

4.2.7 Waste tonnage flexibility

The flexibility of the options to variations in waste tonnage has been considered. Small changes could arise due to seasonal variation however more significant changes could arise due to unexpected waste growth or decline.

The options have been assessed qualitatively based on their suitability to accept and treat a range of waste tonnages. This is split into two sections; the ability of the option to accommodate tonnage increases and the ability to accommodate tonnage decreases. Each has been scored out of a maximum of 5. The scores have been combined to give an overall score for this waste tonnage flexibility criterion.

4.2.8 End product liability

This criterion considers the availability and suitability of markets for the process outputs. There is a greater end product liability associated with a product that has an unproven or under developed market.

The tonnage of each product produced by an option has been multiplied by the corresponding liability weighting. A low weighting indicates a product with an established market. These product liabilities are then combined to give a single liability for the option.

The Authorities' assessment scored the options based on their ranking. This methodology does not consider the range of score obtained. Instead, this assessment scores the options based on their deviation from the mean end product liability.

Table 6 – End product liability weighting			
End Product	**Market**	**Risk of Market**	**Weighting**
Autoclave fibre	Recycling	High	8
Refuse derived fuel (RDF)	Thermal treatment	High	7
Compost Like Output	Land use	High	6
Vitrified residues	Aggregate use	Medium	5
Bottom ash Hazardous material	Aggregate use Landfill	Medium	4
Dry recyclables Residual Waste	Recycling Thermal treatment	Medium	3
Compost (derived from source segregated food waste)	Land use	Low	2
Non hazardous material	Landfill	Low	1

Table 7 – End product liability criteria scoring	
Category	**Score**
-109% to -90% from mean	10
-89% to -70% from mean	9
-69% to -50% from mean	8
-49% to -30% from mean	7
-29% to -10% from mean	6
-9% to +9% from mean	5
+10% to +29% from mean	4
+30% to +49% from mean	3
+50% to +69% from mean	2
+70% to +89% from mean	1
+90% to + 109% from mean	0

4.2.9 Transport

This criterion considers the risks and impacts associated with the transport of waste. Larger distances travelled means a greater risk of accidents, increased congestion and a greater impact on local communities.

The total distance travelled in the transport to site, transfer between sites, and transport to the final destination has been calculated based on the distance used within the WRATE model.

The Authorities' assessment scored the options based on their ranking. This methodology does not consider the range of results obtained. Therefore this assessment has scored the options based on the deviation from the mean transport distance.

Table 8 – Transport criteria scoring	
Category	**Score**
> -90% from mean	10
-89% to -70% from mean	9
-69% to -50% from mean	8
-49% to -30% from mean	7
-29% to -10% from mean	6
-9% to +9% from mean	5
+10% to +29% from mean	4
+30% to +49% from mean	3
+50% to +69% from mean	2
+70% to +89% from mean	1
> +90% from mean	0

4.3 Assessment weightings

In order to determine the best option overall the scores obtained for each assessment criteria must be combined into a single score.

One method would be to simply add each of the scores together. This method would consider each assessment criteria to be equally as important as all of the others. This method was used by the Authorities within their assessment.

In this assessment, however, a weighting system has been used, based on the Authorities' key aims as detailed within the JMWMS. The Joint Members Waste Forum saw Cost, Reliability of Delivery (now Reference facilities) and Resource Depletion as "key criteria". Furthermore, the JMWMS Headline Strategy contains a number of Targets which can be related to other criteria. Target 1 states that a Climate Change target will be set, which would suggest that the Global Warming Potential is a key criterion. Targets 3, 5 and 6 relate to achieving recycling/composting targets, recovering value from waste and reducing the amount of BMW sent to landfill. All three of these Targets would suggest that Diversion from Landfill is also a key criterion. Policy 23 within the Headline Strategy states:

The Partnership will design and operate collection, transfer, associated transport and treatment systems to minimise the overall carbon emissions.

(Policy 23, JMWMS Headline Strategy)

This Policy suggests that Transport is also a key criterion and confirms that the Global Warming Potential is a key criterion.

The reliability of the WRATE data must also be taken into account. The EA have developed guidance for conducting lifecycle assessments using WRATE, which states:

Some life cycle impact indicators such as global warming potential are more rigorous methods because:

- *the gases that contribute to global warming are known;*
- *their impacts occur globally;*
- *their physical attributes can be measured in a laboratory.*

Some indicators are limited in their application because they are based on assumptions concerning the behaviour and potency of releases in idealised ecosystems. There is often not a consensus about methods because they are based on a limited number of observations.

For example, there is a greater degree of uncertainty associated with toxicity impact assessment methods. For these indices, data for toxic substances are assembled from medical literature (where it is available) and the effect of the release is forecast in an idealised environment. As such, Life Cycle Impact indicators provide a proxy for the environmental damage that could occur, providing what is termed a 'potential impact'.

Table 4.2 indicates the relevance of impact assessment methods to different environmental issues. If a more accurate prediction of concentration or toxicity is required for an appraisal, health impact assessment and risk analysis techniques may be necessary.

Table 4.2 Relevance of impact assessment methods

Environmental Issue	***Degree of uncertainty***
Climate change *Non-renewable resource depletion*	*Good degree of certainty*
Acidification *Eutrophication*	*Lesser degree of certainty, but can still be used with a reasonable degree of confidence*
Toxicity effects	*High degree of uncertainty*

(Section 4.2 of Life Cycle Assessment for Integrated Waste Management: practice guidance for waste managers, Environment Agency, 10 July 2007)

Based on this the toxicity categories should have the lowest weighting, whereas global warming and abiotic resource depletion should have the highest.

The reliability of the default processes must also be taken into consideration. The default processes have been used for the MBT, Autoclave and out of county EfWs. These processes have varying reliability due to data inaccuracies, scaling errors and more significantly mass balance errors. This is particularly the case for the default autoclave process where approximately 38% of the input mass is unaccounted for. As it is not possible to penalise one option due to reliability of the software, we have instead weighted all of the environmental criteria less than the other assessment criteria.

Based on the above, a suite of criteria weightings have been developed, these are summarised in Table 9 below.

Table 9 – Assessment category weightings

Assessment category	**Weighting**
Abiotic resource depletion	3
Global warming potential	3
Human toxicity	1
Freshwater aquatic ecotoxicity	1
Acidification	2
Eutrophication	2

Table 9 – Assessment category weightings	
Assessment category	**Weighting**
Capital cost	4
Operating cost	4
Reference facilities	4
Planning risk	3
Landfill diversion	4
Waste composition flexibility	3
Waste tonnage flexibility	3
End product liability	3
Transport	4

4.4 Assumptions

4.4.1 WRATE model

4.4.1.1 Model year

The WRATE model has been developed based on the modelled year 2014. The waste arisings have therefore been based on the arisings for the year 2014/15.

4.4.1.2 Waste tonnage and composition

The composition of municipal solid waste (MSW) has been taken from the Authorities' assessment. Whereas the composition of commercial and industrial (C&I) waste is based on the composition provided within the EA's composition assessment conducted for Yorkshire and the Humber 1998/99.

The tonnage of waste arising modelled is the combination of the expected MSW arisings from the waste collection authorities involved and the quantity of C&I waste required to fill the residual capacity of the proposed Mercia EnviRecover facility (200,000 tpa). These figures are displayed in Table 10 below:

Table 10 – WRATE waste arising	
WCA	**Arisings (tpa)**
Wyre Forest	26,121
Bromsgrove	20,361
Redditch	17,734
Wychavon North	13,803
Wychavon South	16,646
Worcester City	20,198
Malvern Hills	15,285
Hereford South (Leominster)	12,389
Hereford North (Rotherwas)	28,383

Table 10 – WRATE waste arising	
WCA	**Arisings (tpa)**
Total MSW	**170,920**
C&I	29,080
Total	**200,000**

The modelled composition of these waste streams are summarised in Table 11.

Table 11 – WRATE waste composition			
Waste component	**MSW**	**C&I**	**Combined Stream**
Paper/card	16.28 %	43.68 %	20.26 %
Plastic film	7.30 %	7.96 %	7.40 %
Dense Plastic	6.27 %	6.98 %	6.37 %
Textiles	3.27 %	0.00 %	2.79 %
Absorbent hygiene	4.31 %	0.00 %	3.68 %
Wood	0.56 %	3.18 %	0.94 %
Combustibles	0.65 %	6.99 %	1.57 %
Non-combustibles	6.62 %	0.18 %	5.68 %
Glass	3.87 %	6.34 %	4.23 %
Organic	46.87 %	16.61 %	42.47 %
Garden Waste	0.00 %	0.44 %	0.06 %
Ferrous	1.82 %	3.42 %	2.05 %
Non-Ferrous	0.66 %	0.50 %	0.64 %
Fines	0.70 %	1.24 %	0.78 %
WEEE	0.57 %	0.88 %	0.62 %
Hazardous	0.25 %	1.60 %	0.45 %

4.4.1.3 Electricity mix

WRATE's default electricity mix for the UK in 2014 has been used. This is summarised in Table 12 below.

Table 12 – WRATE's 2014 UK electricity mix			
Energy Source	**Baseline Fuel Mix**	**Generating Efficiencies**	**Marginal Fuel Mix**
Coal	32.50	35.70	48.10
Oil	0.30	33.10	0.00

Table 12 – WRATE's 2014 UK electricity mix			
Energy Source	**Baseline Fuel Mix**	**Generating Efficiencies**	**Marginal Fuel Mix**
Gas	3.04	34.90	3.30
Gas CCGT	36.60	47.60	48.60
Nuclear	13.90	38.60	0.00
Waste	0.20	20.60	0.00
Thermal Other	0.80	18.70	0.00
Renewables thermal	2.30	25.80	0.00
Solar PV	0.10	15.50	0.00
Wind	8.40	25.00	0.00
Tidal	0.10	82.00	0.00
Wave	0.10	82.00	0.00
Hydro	1.30	82.00	0.00
Geothermal	0.00	82.00	0.00
Renewable Other	0.00	82.00	0.00
Total	**100.00**		**100.00**

4.4.1.4 Bespoke Processes

Two bespoke processes have been developed for the WRATE modelling based on the proposed Mercia EnviRecover facility. One represents the facility exporting power only, whereas the second reflects the facility exporting both heat and power.

The electricity-only EfW was based on an adaptation of the default WRATE process for 'Billingham'. This was chosen as it is the closest default process within WRATE to the proposed facility in terms of both technology and throughput. The Billingham process was modified to more accurately model the expected performance of the proposed Mercia EnviRecover facility.

The CHP EfW was based on a further adaptation of the electricity-only model, allowing for the export of heat. This has been based on the assumption that 10 MW_{th} of heat is exported. The environmental impact of the heat export infrastructure has not been considered in this model as the type of infrastructure can vary considerably, depending on the heat requirement.

An addition bespoke process has been developed for an AD facility processing food waste. The input waste composition defines all organic material as "unspecified organic." The default AD processes in WRATE can only accept waste categorised as "food waste" or "garden waste." The bespoke process has removed this restriction to allow the process to accept the incoming waste.

Finally, a bespoke process was created to allow the separation of waste streams. This process was developed only for ease of modelling. It is not used to represent actual facilities, and therefore has no environmental impacts.

The full details of the adjustments made to the allocation tables are given within Appendix A.

4.4.1.5 Transport Assumptions

Where possible the actual distances by road for waste and other material transport have been identified for use in the model.

The waste from each waste collection authority (WCA) is assumed to arise at a particular point in the collection area, and it is from this point that transport distances are measured to treatment/disposal sites. Where destinations for residues and products (such as APC residues and bottom ash) are known these distances have also been used.

In cases where the transport distances are unknown, the EA approved typical distances have been used as appropriate to each journey. (i.e. 25 km has been used for transportation within the county, whereas 50 km has been used for transportation within the region.)

The WRATE default journey breakdowns (urban, rural and motorway fractions) for each vehicle type were used. These defaults are supplied by the EA as part of the WRATE software package.

The full details of each transport element of the scenarios modelled are set out in Appendix B, with justifications of all the selections made.

In any case where a Waste Transfer Station (WTS) is located at the point where waste is assumed to arise, no transport is modelled between the waste arising and the loading station.

In all cases, where RCVs are modelled the '6x4 RCV – ULS Diesel' (ID 12278) has been selected as they represent a typical RCV fleet. Where front-end loaders are modelled the process '6x4 FEL' (ID 12009) has been selected. The bulk transport is represented by the default intermodal transport process (ID 12026) and the RO-RO vehicles by the default process (ID 12279).

4.4.1.6 Option 1 – 1 site EfW (Power only)

This option models the proposed Mercia EnviRecover facility exporting power only. It consists of a single EfW facility treating waste at the Hartlebury site.

Transportation between the waste collection authorities (WCAs) and the site varies between the authorities modelled; for the Wyre Forest, Bromsgrove, Wychavon North, Worcester City and Malvern Hills authorities a proportion of their waste is modelled as being transported directly to the Hartlebury site in refuse collection vehicles (RCVs). The remaining waste is assumed to be taken to one of three loading stations (Redditch, Rotherwas, Leominster and HML) where waste is bulked. The waste is then transported to the Hartlebury site in bulk 'intermodal' vehicles which are more efficient than RCVs for carrying bulk loads of waste.

The EfW facility is modelled using the user-defined Mercia EnviRecover process, which has been developed based on the default Chineham process.

Bottom ash from the modelled EfW is assumed to be transported to Ballast Phoenix in Castle Bromwich for recycling and APC residues are transported to Bishop's Cleeve hazardous landfill in Gloucestershire for disposal. The IBA recycling modelled is one which includes recovery of metals (process ID 12028). Ferrous metals recovered at the EfW are assumed to be transported to a reprocessor within the county.

Figure 1 shows the process flows for this case:

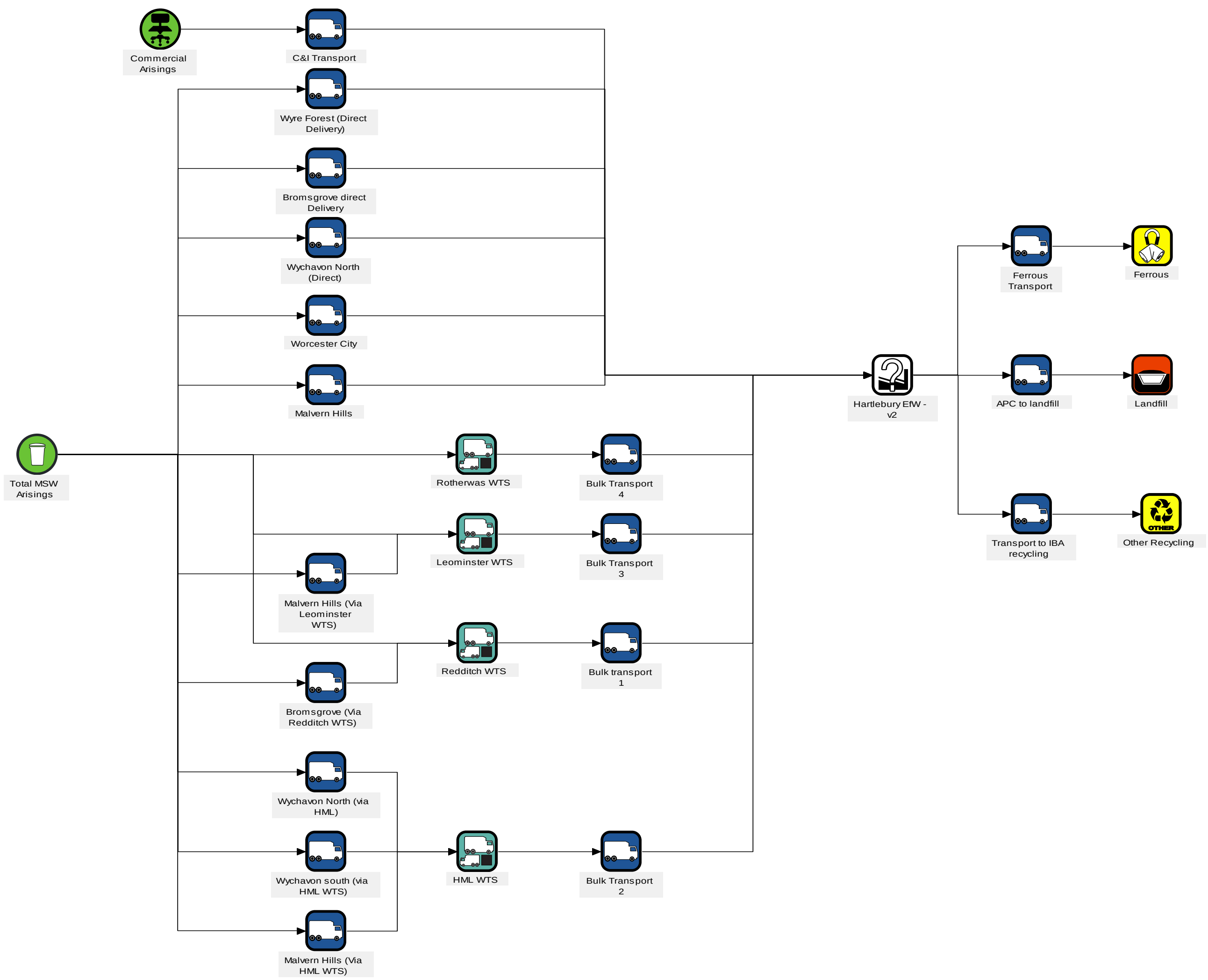


Figure 1 – Option 1 process flows

4.4.1.7 Option 2 – 1 site EfW (CHP)

This option models the proposed Mercia EnviRecover facility exporting both heat and power at the Hartlebury site. This is also modelled using a user-defined process, which is based on the power only Mercia EnviRecover EfW process, modified such that both heat and power are exported. The environmental impacts associated with the heat export infrastructure are not modelled as heat could be exported in a number of forms, with varying infrastructure requirements.

All other model assumptions remain the same as option 1. The process flows for this option are shown in Figure 2:

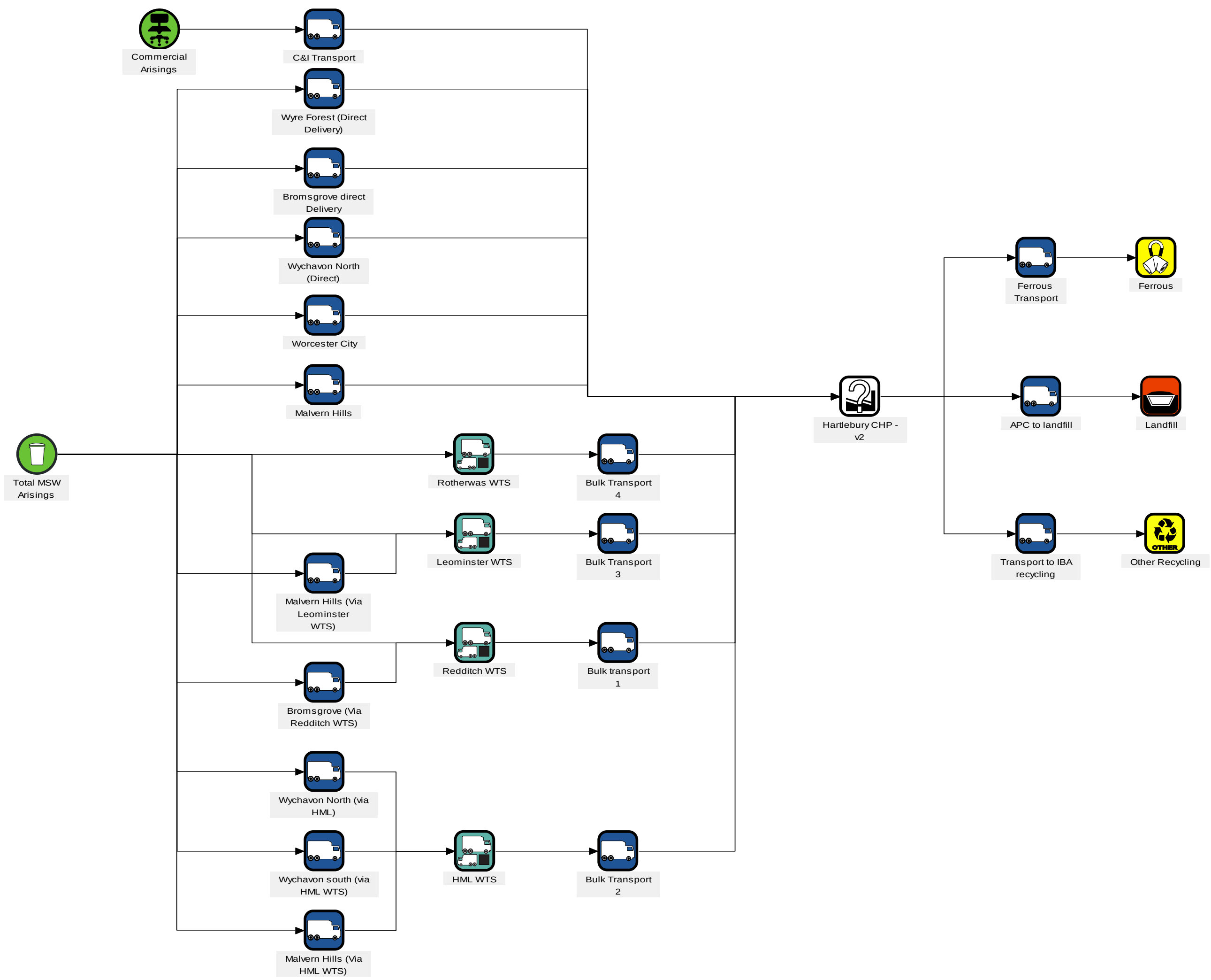


Figure 2 – Option 2 process flows

4.4.1.8 Option 3 – Out of county EfW

This option is based on utilisation of out of county third party EfW facilities to treat the waste. Waste is landfilled within county up to the Authority's LATS allowance at the HML landfill. The remaining waste transported to out of county facilities.

Approximately 90,000 tpa is transported to the Allington EfW in Kent. The WRATE model assumes the 'Dundee' process (ID: 11047) as this is also a fluidised bed facility and so should be a fair representation of the Allington plant.

There are certain limitations associated with this assumption. The modelled throughput is within approximately 25% of the Dundee facility's capacity. This is slightly greater than the EA's recommendation that the default processes are not scaled by more than 10%. However there are no other fluidised bed default processes. The composition used in this model will also impact on the accuracy of the model as it will differ from the Dundee process' design composition. As WRATE EfW processes operate using scaling of relationships between input and output materials, rather than combustion calculations, this can result in inaccuracies when such processes are applied in contexts outside their typical operating compositions.

Approximately 65,000 tpa of waste is transported to the EfW in Coventry which has been modelled with WRATE's default process for Coventry (ID 13401).

The default process for Coventry has been used, although some errors are thought to exist within the default process. This process is also particularly susceptible to inaccuracy when used with compositions away from its design composition. As the typical composition for which the Coventry model was designed is somewhat different to that supplied to this facility, the scaling for ash, CO_2 and other burdens is not as accurate as it would be if the typical waste composition was used.

The process has also been scaled down considerably from 315,000 tpa to represent the fraction of the environmental impact of the facility which can be apportioned to the Hereford and Worcester waste stream of approximately 109,000 tpa (approx 65% reduction). This is again larger than the EA's recommended scaling for default processes.

The process flows for this option are shown in Figure 3:

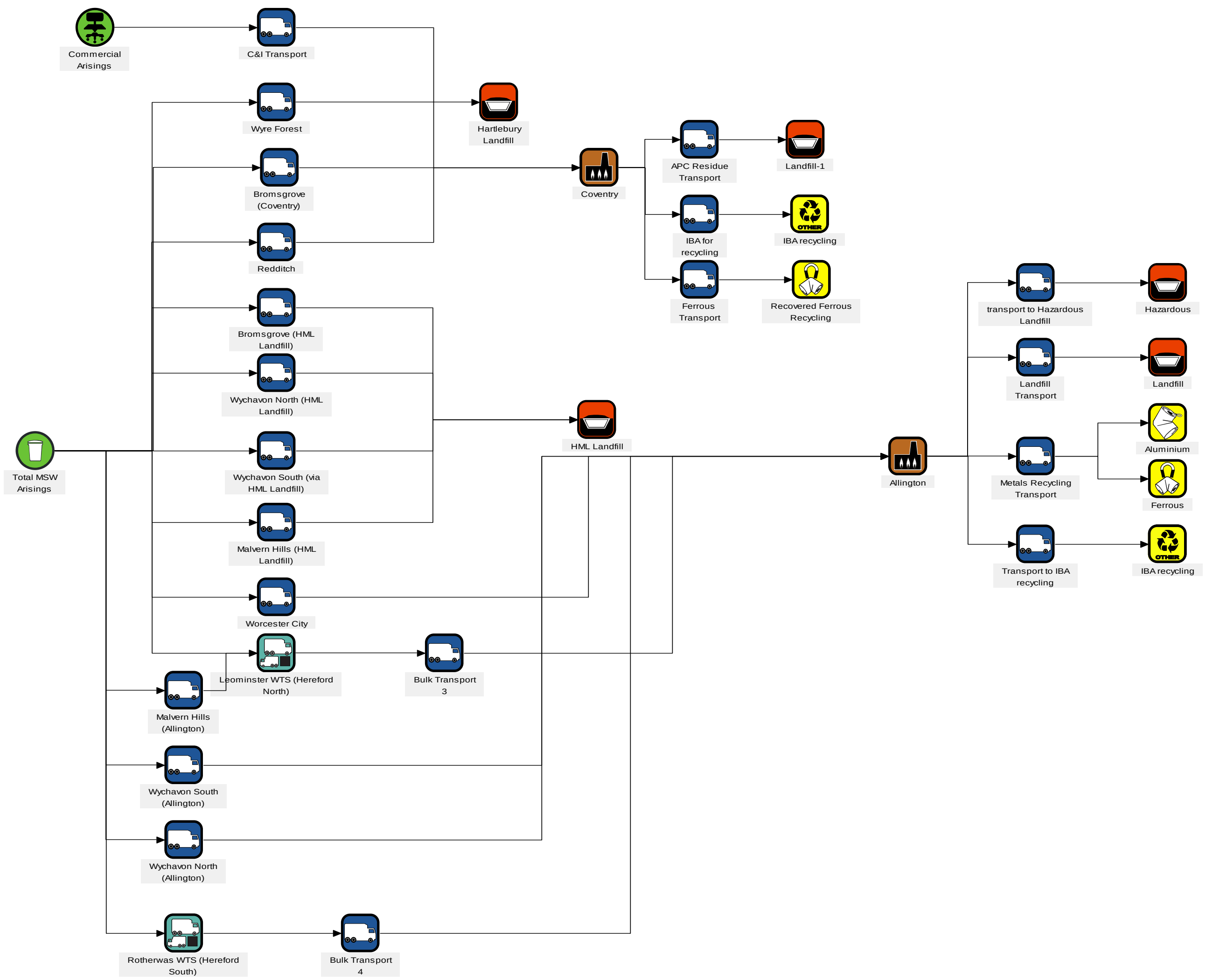


Figure 3 – Option 3 process flows

4.4.1.9 Option 4 – 1 site Autoclave with the fibre recycled as fibreboard

The fourth option modelled is an autoclave facility at the Hartlebury site. Metals, plastics, fibre and glass are recovered for recycling and the residual material is landfilled.

The modelled facility is based on the 'ESTECH' process (ID 11325) which separates recyclables and produces fibre for use in the manufacture of fibreboard. It is important to stress that this technology is based on a process which only exists as a pilot plant and is therefore unproven on this scale. Although more proven autoclave technologies, such as Sterecycle, do exist, these are not available as default processes within WRATE.

This process appears to suffer from a significant unexplained mass loss in the process which is likely to considerably skew the results from the WRATE model. In addition the performance of this 200,000 tpa WRATE model is actually based on scaling up the performance of a 1 tph pilot plant and the outputs have therefore not been validated. As such, any predictions from this model should be interpreted with these limitations in mind.

However, this is the EA's approved process for autoclave modelling and therefore has been used within this assessment.

The transportation to the Hartlebury site is modelled as being the same as described for the EfW and EfW CHP cases.

The recovered material from the autoclave is modelled as being transported to a recycling facility for processing into fibre-board. It should be noted that such treatment is not common in the UK.

The process flows for this option are shown in Figure 4:

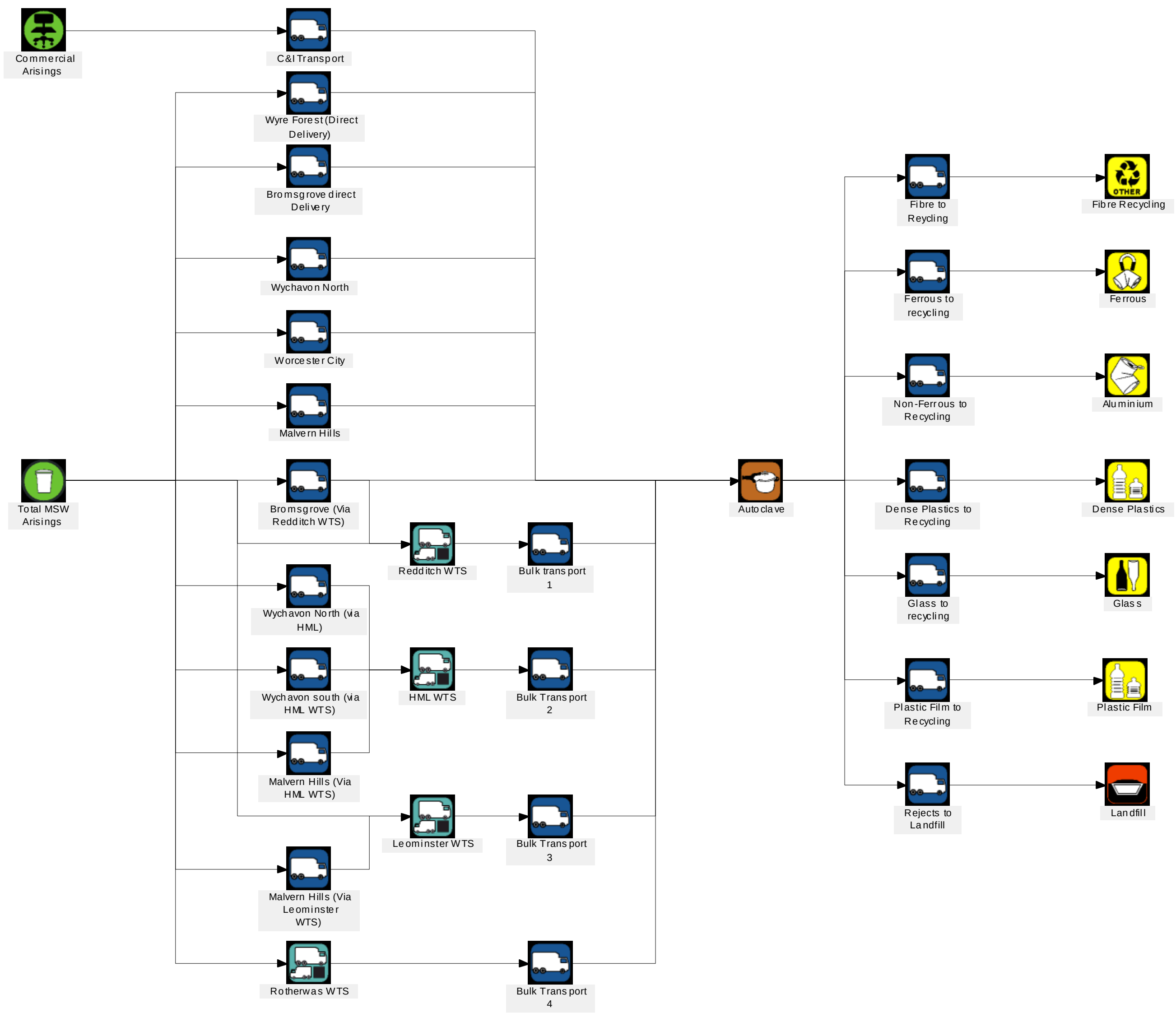


Figure 4 – Option 4 process flows

4.4.1.10 Option 5 – 1 site Autoclave with the fibre landfilled

Option 5 is based on the same process as option 4. The only difference is that the fibre is not able to be marketed and thus is landfilled. This option therefore still has the same limitations and potential errors as discussed above.

The fibre is assumed to be transported to the same landfill as the rejected waste.

The process flows for this option are shown in Figure 5:

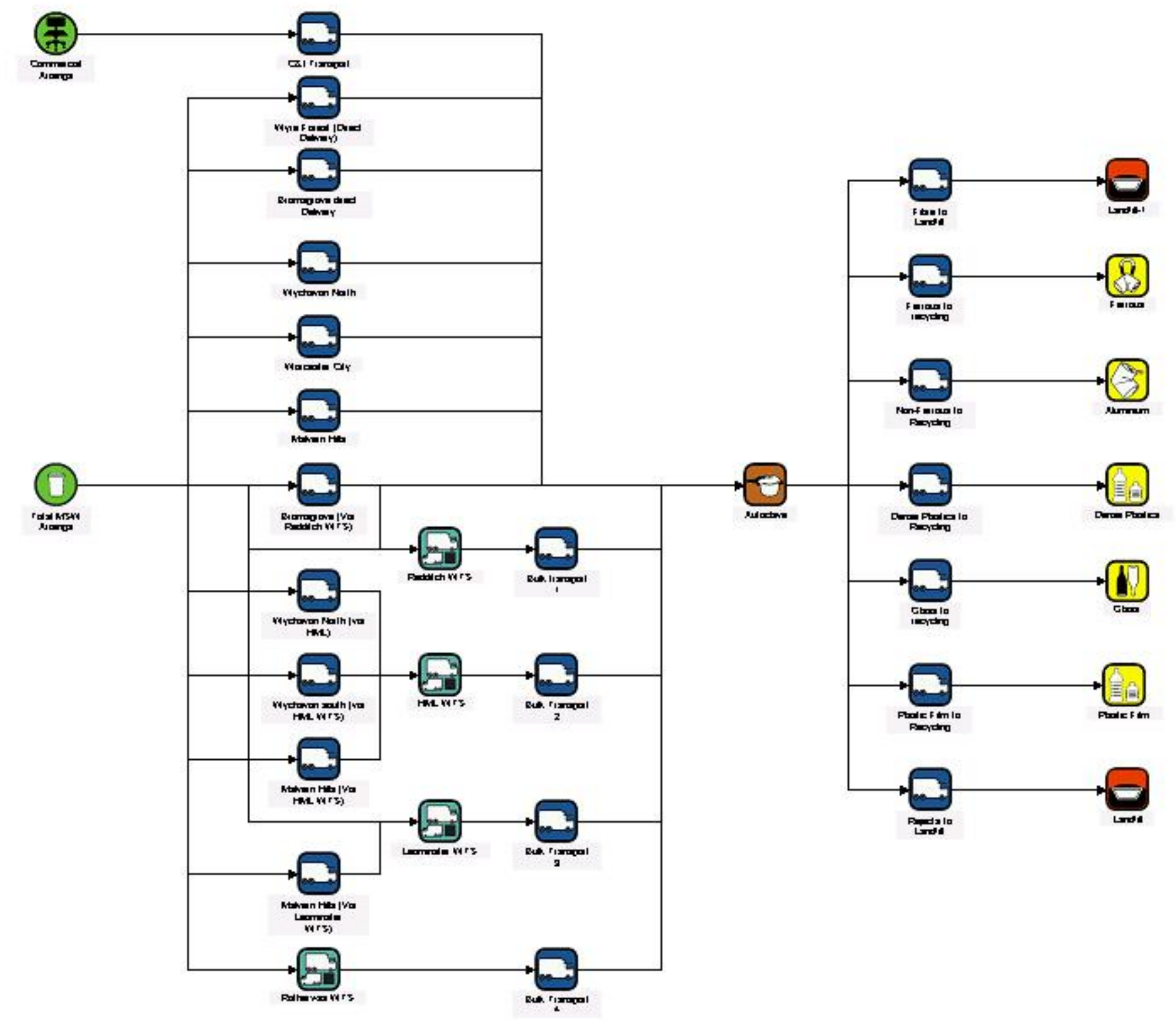


Figure 5 – Option 5 process flows

4.4.1.11 Option 6 – 2 site Autoclave with the fibre recycled as fibreboard

This option uses two sites, one at Hartlebury and one at Madley Airfield (Hereford). An autoclave facility is located at both sites. As in option 4, metals, plastics, fibre and glass are recovered for recycling and the residual material is landfilled. The same autoclave process is used in this option as in option 4, and therefore the same limitations apply.

Figure 6 shows the layout for this scenario.

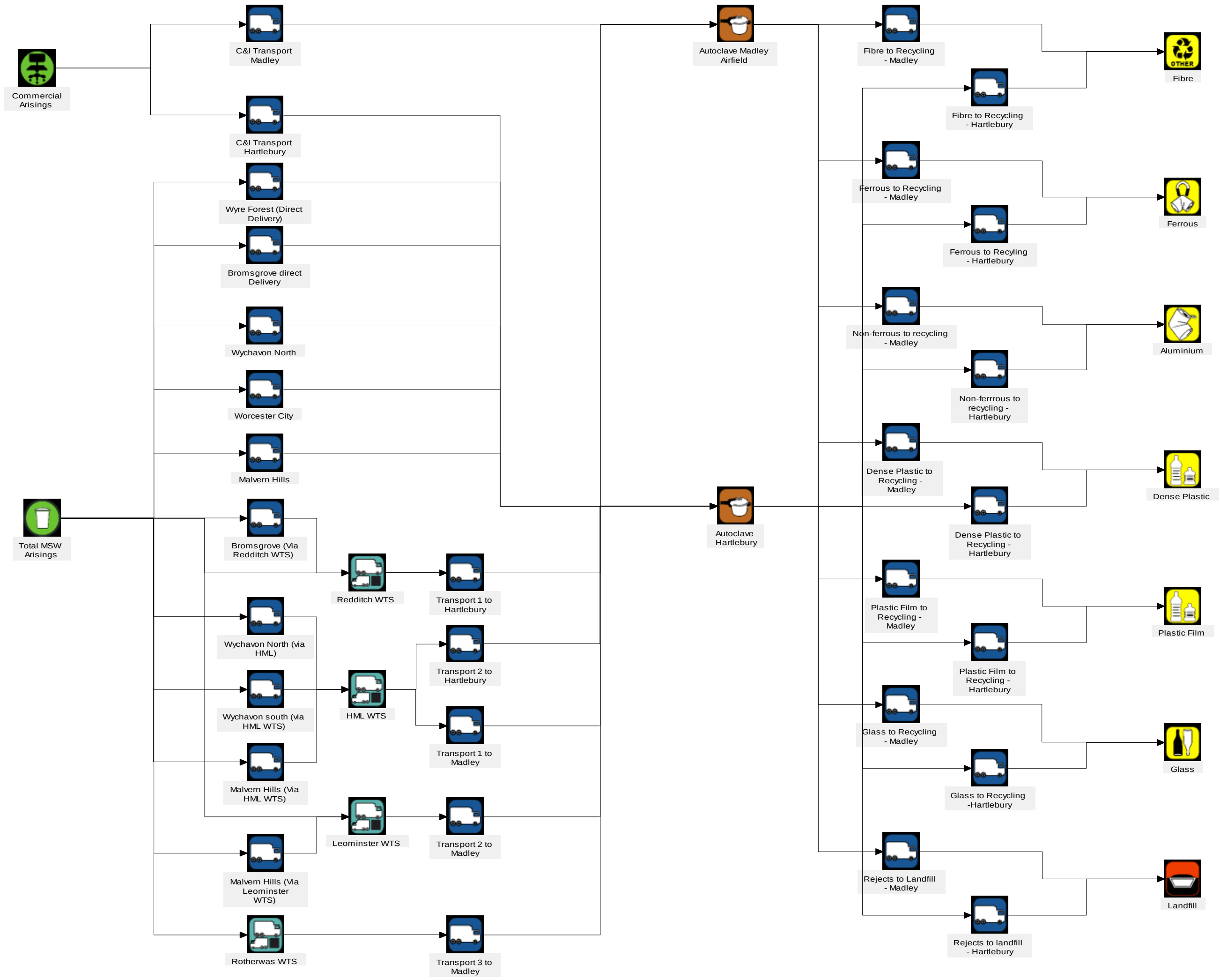


Figure 6 – Option 6 process flows

4.4.1.12 Option 7 – 2 site MBT with on-site combustion of the RDF

This option is based on two facilities, located at Hartlebury and Madley.

The Madley site is modelled as having an MBT facility producing a RDF with a biodrying process. This process involves the rejection of unsuitable waste to landfill, separation of recyclable material (glass and metals) and the production of the bio-dried RDF made up of the remaining waste material.

The Hartlebury site is modelled with a similar MBT facility and an EfW which would be fuelled by the RDF produced on both sites. The transport of extracted recyclates for processing within the county and the transfer of RDF from Madley to Hartlebury is also modelled.

The MBT facilities are modelled using default WRATE processes. These are based on the 'ECODECO' biodrying RDF production process (ID 11216). Recyclables are separated for removal from site, and RDF is produced for combustion EfW facilities.

As with the other facilities which are scaled from default WRATE processes, the environmental burdens of the bespoke MBT facilities have been scaled from the original design throughput of 65,000 tpa to 66,000 tpa and 134,000 tpa for the two sites modelled. This may introduce inaccuracies in the predicted environmental impact, particularly in the case of the Hartlebury facility for which the throughput is highest (over double the design throughput for the process).

The EfW modelled is based on the bespoke Mercia EnviRecover facility developed in order to demonstrate the environmental impact of treating the RDF at a new facility based on a smaller version of the proposed facility.

As in previous scenarios using the bespoke Mercia EnviRecover facility, ferrous metals are recovered at the EfW and are transported to an in county reprocessor. Once again the IBA reprocessing model used includes metals recovery as although metals are removed in the MBT facilities and at the EfW it is likely there will be residual metals in the bottom ash produced by the EfW.

Figure 7 shows the process flows for this option:

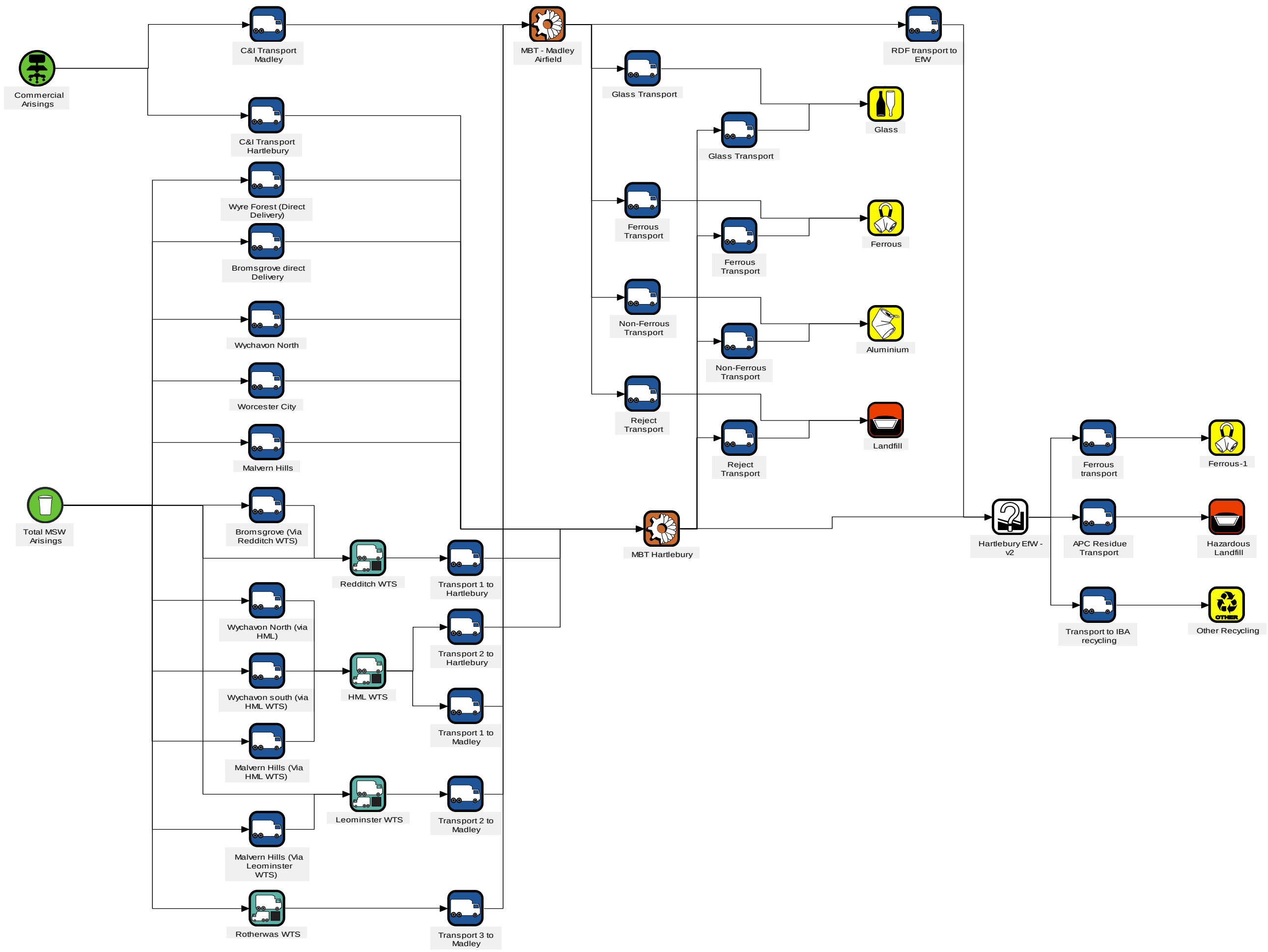


Figure 7 – Option 7 process flows

4.4.1.13 Option 8 – 2 site MBT with out of county combustion of the RDF

The eighth option modelled uses the same sites and MBT facilities as modelled in option 7. In this case however, the RDF produced by the MBT plants is modelled as being transported to an out of county EfW facility. In this case it has been assumed to be the large merchant RDF power station to be built at Runcorn in Cheshire. An alternative would be to send the RDF to a cement kiln, but there is limited capacity within existing cement kilns.

The RDF is modelled as being transported by road in bulk using intermodal vehicles. The transport of the extracted recyclates for processing within the county has also been modelled.

In this model the bespoke Mercia EnviRecover facility has been used to represent Runcorn. This model has been chosen to allow a fair comparison with the other similar cases and because the details of the Runcorn merchant facility are not available. As explained in the previous section, the significant scaling of this model to approximately half of design throughput may introduce inaccuracies into the WRATE results.

Figure 8 shows the process flows for this option.

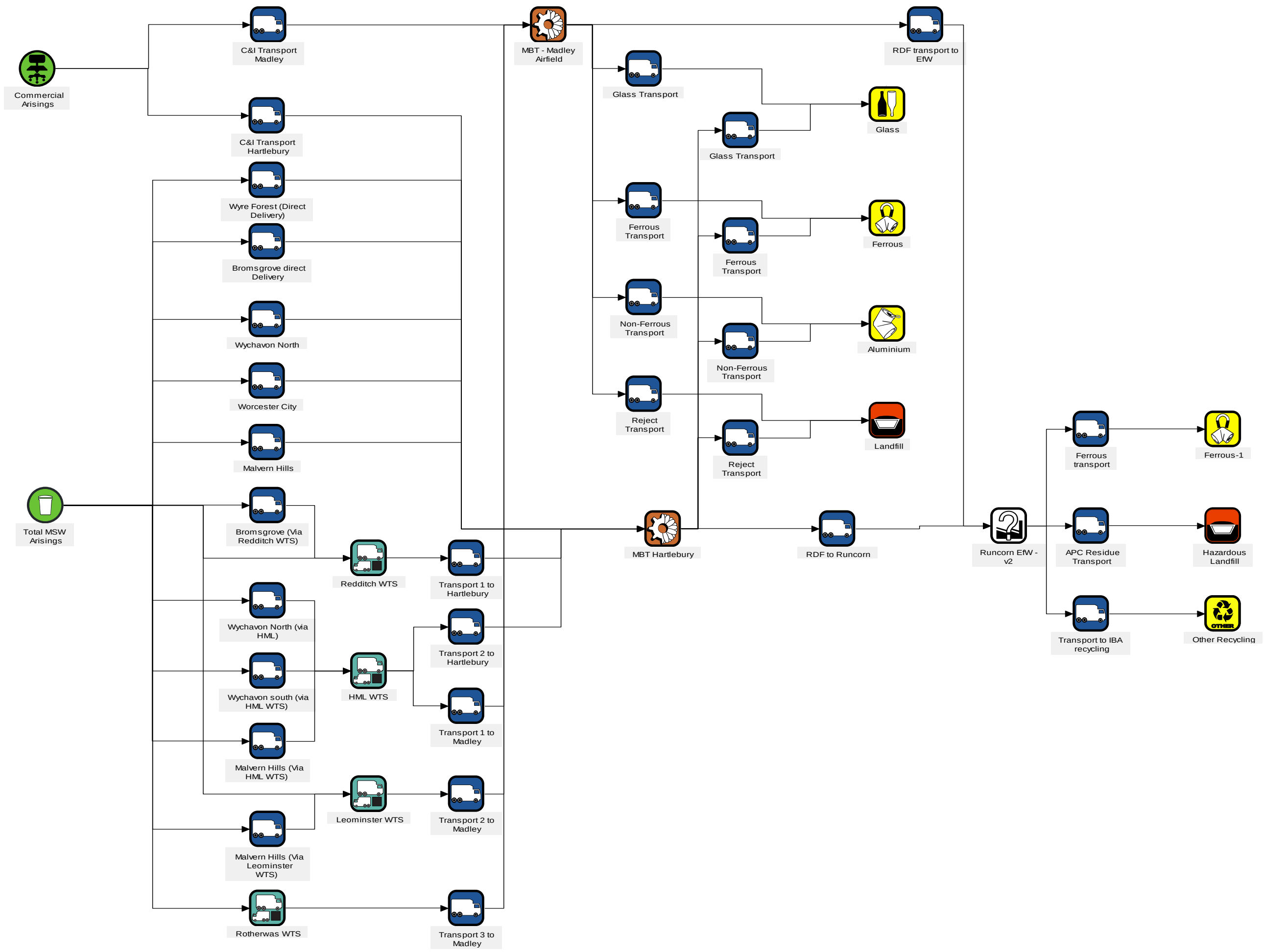


Figure 8 – Option 8 process flows

4.4.1.14 Option 9 – Out of county EfW with food waste treated by AD

The ninth option modelled uses the same out of county EfW facilities as in Option 3 (out of county EfW). In this case however, food waste is separately collected from all households and is delivered to an AD facility on the Hartlebury site for processing. The amount of segregated food collected in the WRATE model has been based on the tonnage of food waste currently collected under the Wychavon food collection scheme compared to the overall arrisings. Approximately 20,000 tonnes of food waste in total are sent to the AD facility.

The transport of food waste to the Hartlebury site uses the same transport distances, vehicles and transfer stations as modelled in Options 1 and 2 (Hartlebury EfW). This is to ensure that the various options are compared consistently.

The AD process is a bespoke process based on the WRATE default STRABAD AD process (21263). This process has been modified to allow it to process unspecified organics as this is the category that is defined in the input waste composition.

The output from the AD process is sent for use as compost in the default WRATE compost use process for AD cake (12298).

Figure 9 shows the process flows for this option.

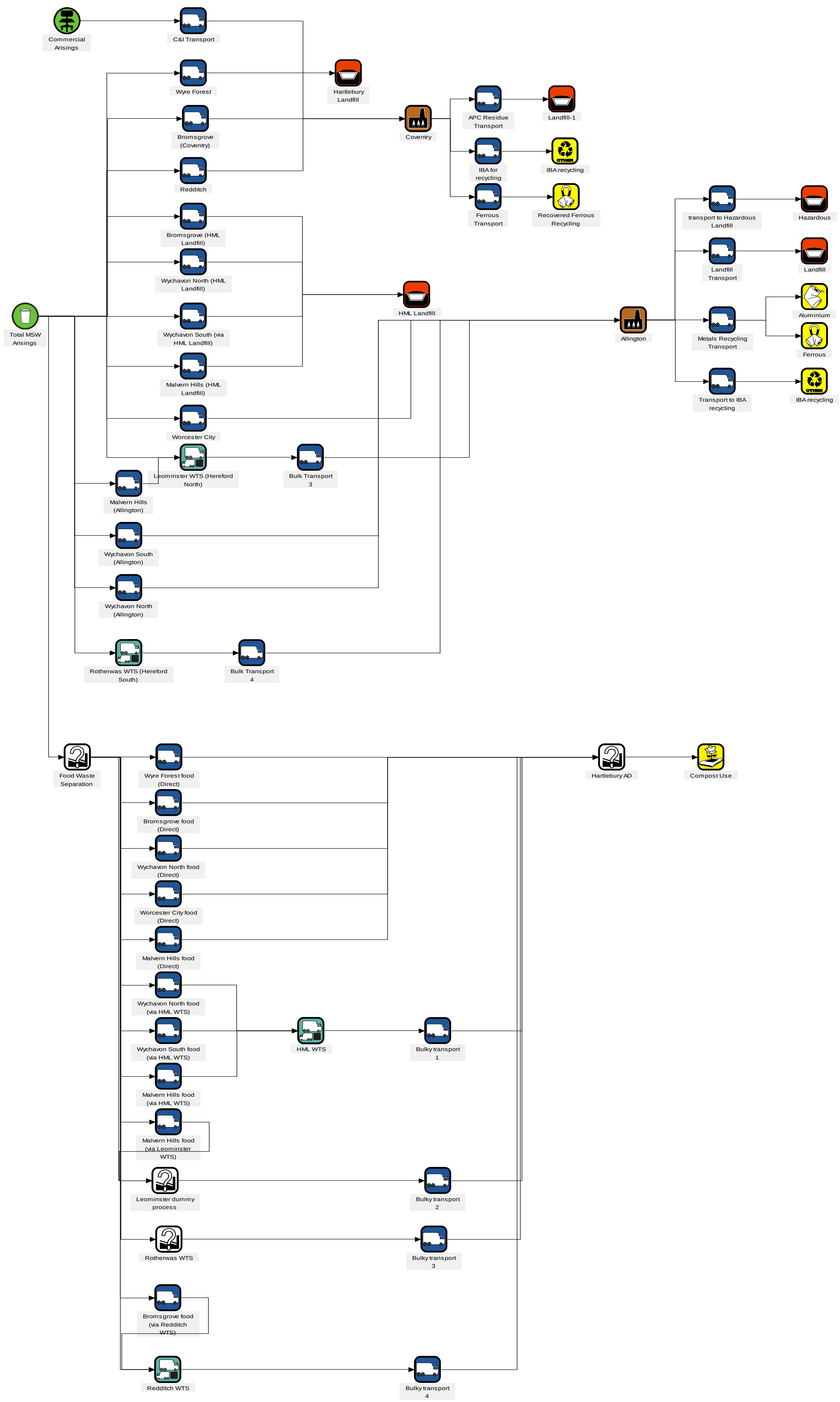


Figure 9 – Option 9 process flows

4.4.1.15 Option 8a – Sensitivity on Option 8

In addition to the nine options discussed above, an additional sensitivity was also run on Option 8. This sensitivity, Option 8a, examines the impact on an increase in the efficiency of the Runcorn EfW on the overall scoring of the Option. This sensitivity was included because as a large facility, the net electrical efficiency of the Runcorn facility may be higher than that assumed in the bespoke process for the Hartlebury EfW.

The process flow for Option 8a is identical to that for Option 8 shown in Figure 8.

4.4.2 Mass & energy balances

4.4.2.1 Mercia EnviRecover EfW (Power only)

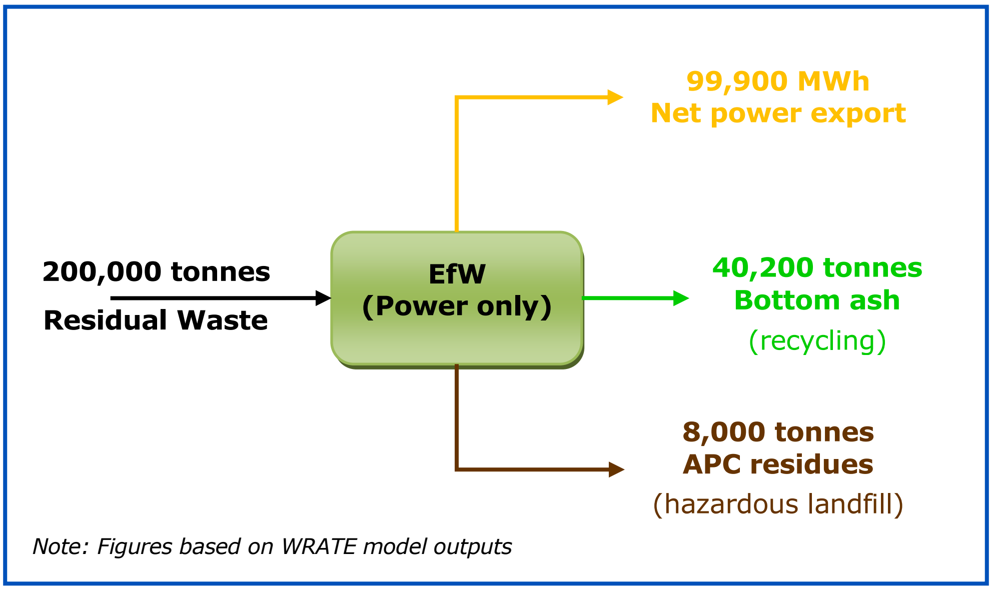


Figure 10 – Mass and energy balance for power only EfW

4.4.2.2 Mercia EnviRecover EfW (CHP)

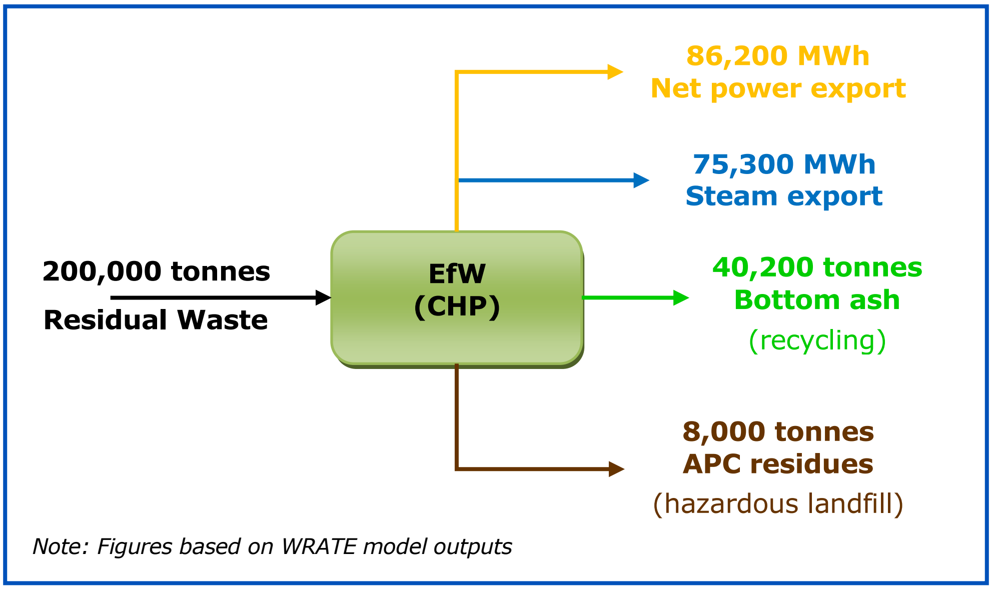


Figure 11 – Mass and energy balance for CHP EfW

4.4.2.3 Autoclave

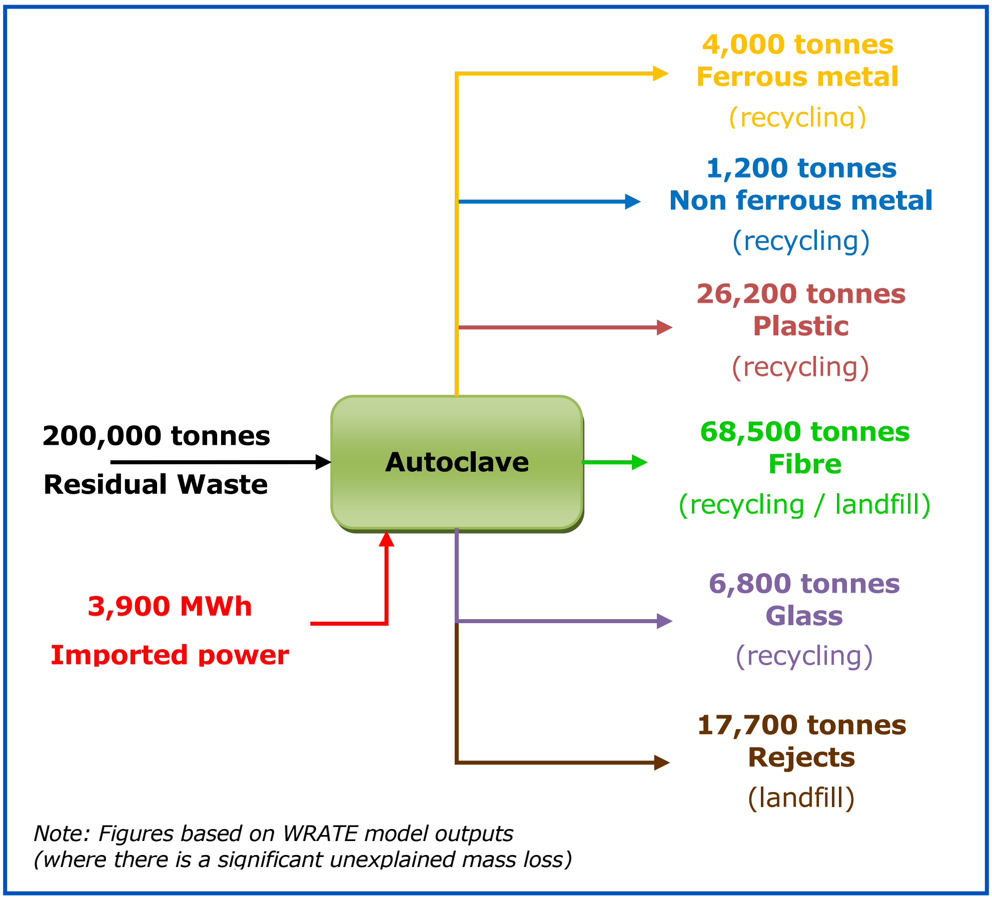


Figure 12 – Mass and energy balance for Autoclave

4.4.2.4 MBT

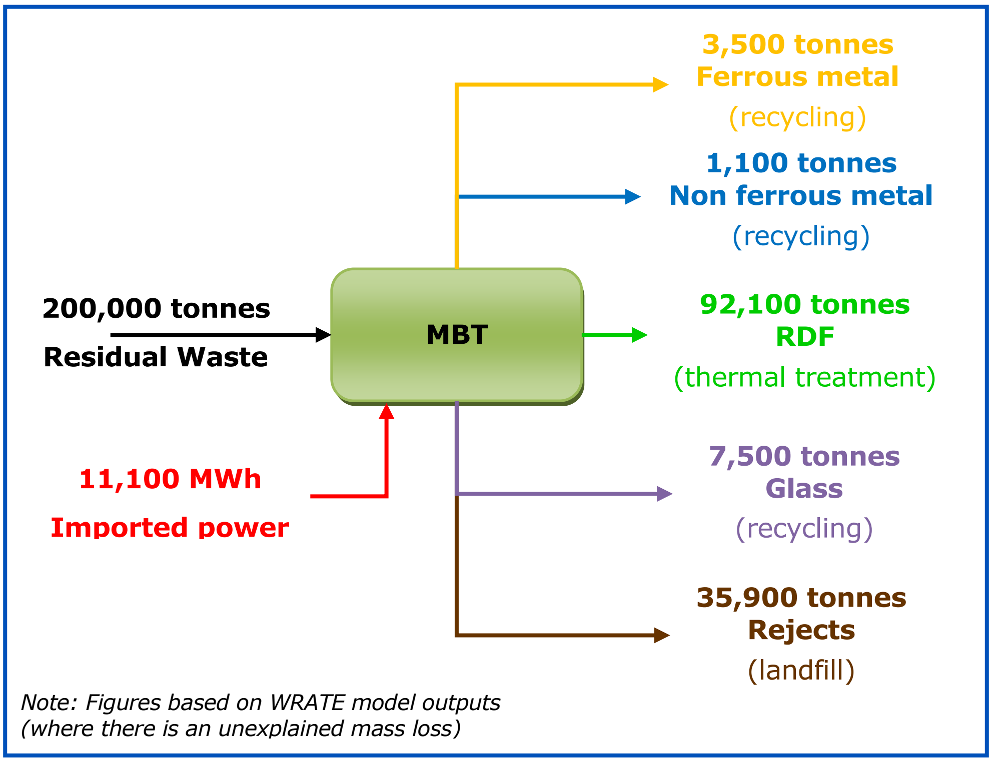


Figure 13 – Mass and energy balance for MBT

4.4.3 Financial

4.4.3.1 Capital costs

Engineering, Procurement and Construction (EPC) cost estimates have been made based on Fichtner's experience of recent projects of a similar nature and size. These have been scaled accordingly for age of data and facility capacity.

The total capital investment for each option is based on the combination of the EPC cost and other development costs. These development costs include; planning and permitting costs, enabling works, grid connection and also the Owner's Engineer fee during construction. These costs have been based on Fichtner's experience and assume no site specific requirements. The multiple site options take into account work already conducted. For example a second planning application would cost less than the first application, whereas enabling works would cost approximately the same for the second site.

The capital cost of the heat export distribution system has not been included within this assessment. It is assumed that the distribution network operator will invest the capital to construct the infrastructure. The steam would then be sold from the facility to the distribution network operator at a reduced cost so that the sale of the heat to end users would supply the income to pay back the capital investment. Furthermore, the cost of the distribution network will vary significantly depending on the quantity and quality of the heat exported and also the end user location.

4.4.3.2 Operating costs

Operating costs have been estimated based on a number of assumptions detailed within Table 13 below. All costs have been estimated for the year 2014/15.

Table 13 – Operating cost assumptions		
Assumption	**Value**	**Comment**
Transportation cost	-£1.80 per mile	Fichtner assumption
Ferrous metal recycling	+£20 per tonne	Assumes market will begin to return to similar levels pre economic downturn
Non-ferrous metal recycling	+£400 per tonne	Assumes market will begin to return to similar levels pre economic downturn
Plastics recycling	+£70 per tonne	Assumes market will begin to return to similar levels pre economic downturn
Glass recycling	+£5 per tonne	Glass from autoclaves is typically an aggregate quality and so the revenue reflects this
Fibre to fibreboard recycling	-£30 per tonne	Assumes a gate fee is required to send fibre to fibreboard recycling
AD digestate to recycling	-£5 per tonne	Assumes a nominal gate fee is required to send AD digestate to recycling
Waste to EfW facility	-£90 per tonne	Estimated gate fee
RDF to EfW facility	-£90 per tonne	Assumed to be the same as waste to EfW
Bottom ash recycling	-£10 per tonne	Estimated gate fee for bottom ash recycling plant
Rejects to landfill	-£30 per tonne	Estimated gate fee for active landfill
Fibre to landfill	-£30 per tonne	Estimated gate fee for active landfill
APC residue to hazardous landfill	-£150 per tonne	Estimated gate fee for hazardous landfill
Active landfill tax	-£72 per tonne	Based on current legislation
Imported power	-£60 per MWh	Based on typical Lenders' assumption regarding future power prices
Net power exported	+£40 per MWh	Based on typical Lenders' assumption regarding future power prices
Heat exported	+£10 per MWh	Low cost assumed to be sold to distribution company
RHI	1 RHI / MWh of steam exported	Based on the draft RHI consultation
RHI	+£26 per RHI	Based on the draft RHI regulation
LEC	0.6 LEC / MWh of electricity	Based on an assumed bioenergy content of 60%
LEC	+£4.50 per LEC	Based on a conservative assumption assuming 2.5% inflation
Staffing	Various	Based on Fichtner's experience of staffing levels and typical payroll costs
Consumables	Various	Based on Fichtner's experience and typical unit costs
Misc. other costs (overheads, lease fees, transmission charges, rates etc)	Various	Based on Fichtner's experience of typical misc. other costs for individual sites

5 Options Appraisal

5.1 Abiotic resource depletion

The abiotic resource depletion results have been obtained from the WRATE model. These are shown graphically within Figure 14. A negative value indicates an environmental benefit whereas a positive value indicates an environmental burden.

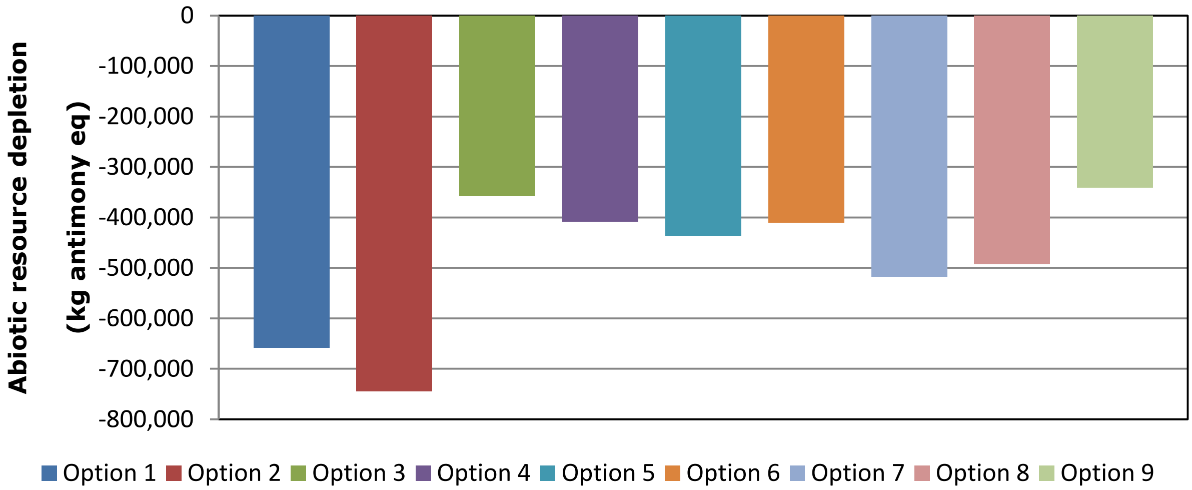


Figure 14 – Abiotic resource depletion results

Options 1 and 2 score highly, because the power and heat generated offset fossil fuel use at power stations. Option 3 does not score as well as options 1 and 2 due to the fuel usage in transporting the waste to the out of county EfW. The autoclave options (4 to 6) produce recyclables therefore offsetting virgin materials. However autoclaves use fossil fuels to heat the waste within the process, which means that overall they do not perform as well as Option 1. Options 7 and 8 also offset power production; however, due to the reduced tonnage of material generating energy these do not perform as well as Option 1. The performance of Option 9 is very similar to Option 8 as the addition of an AD facility has very little impact on resource depletion.

The options have been scored based on their deviation from the mean, as summarised within Table 14 below.

Table 14 – Abiotic resource depletion assessment scores

Option	Score
1. Mercia EnviRecover Facility (Power only)	7
2. Mercia EnviRecover Facility (CHP)	8
3. Out of County EfW	4
4. 1 site Autoclave (Fibre recycled as fibreboard)	4
5. 1 site Autoclave (Fibre landfilled)	4
6. 2 site Autoclave (Fibre recycled as fibreboard)	4
7. 2 site MBT with on-site combustion of the RDF	5
8. 2 site MBT with out of county combustion of the RDF	5

Table 14 – Abiotic resource depletion assessment scores	
Option	**Score**
9. Out of County EfW with food waste AD	3

5.2 Global warming potential

The global warming potential results have been obtained from the WRATE model. These are shown graphically within Figure 15. A negative value indicates an environmental benefit whereas a positive value indicates an environmental burden.

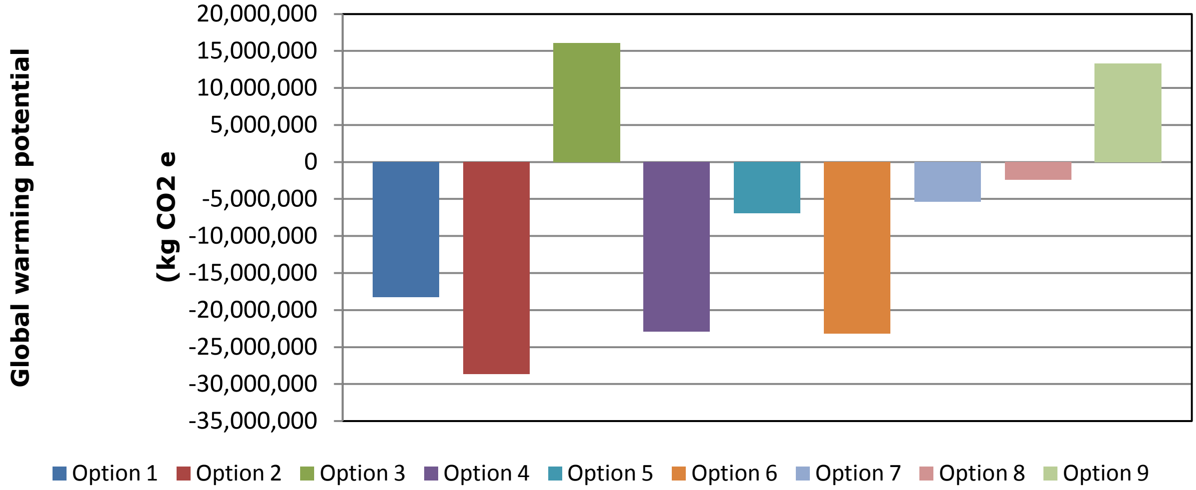


Figure 15 – Global warming potential results

Option 3 and Option 9 have a significant global warming potential burden; this is due to both the significant distance travelled to out of county facilities and the tonnage of waste landfilled. Option 9 performs better than Option 3 due to the power produced in the AD facility which offsets electricity generation. Option 2 performs better than Option 1 due to the inclusion of the heat export, which offsets boiler use. Options 4 and 6's performance is similar to Option 2, due to the recycling of fibre and other dry recyclables offsetting virgin material. Option 5 performs significantly worse than Option 4 due to the landfilling of the fibre. Options 7 and 8 demonstrate an environmental benefit due to the power generation and materials recycling. Option 7 does not perform as well as option 1 due to the reduced power generation and increased rejects to landfill. Option 8 performs worse than option 7 due to the significant distances travelled to the offsite combustion.

The options have been scored based on their deviation from the mean, as summarised within Table 15 below. Due to the significant variation within the results the scoring boundaries were scaled so that all options fell within the bounds zero to ten.

Table 15 – Global warming potential assessment scores	
Option	**Score**
1. Mercia EnviRecover Facility (Power only)	10
2. Mercia EnviRecover Facility (CHP)	10
3. Out of County EfW	0

Table 15 – Global warming potential assessment scores	
Option	**Score**
4. 1 site Autoclave (Fibre recycled as fibreboard)	10
5. 1 site Autoclave (Fibre landfilled)	4
6. 2 site Autoclave (Fibre recycled as fibreboard)	10
7. 2 site MBT with on-site combustion of the RDF	3
8. 2 site MBT with out of county combustion of the RDF	1
9. Out of County EfW with food waste AD	0

Due to the large range of global warming impact, many of the solutions showed deviations from the mean large enough to lead to a score of either 0 or 10. For example, both Option 3 (out of county EfW) and Option 9 (out of county EfW with added AD) scored 0. This is because both options were more than 100% greater than the mean value, even though in absolute terms Option 9 showed less of an environmental burden than Option 3.

5.3 Human toxicity

The human toxicity results have been obtained from the WRATE model. These are shown graphically within Figure 16. A negative value indicates an environmental benefit whereas a positive value indicates an environmental burden.

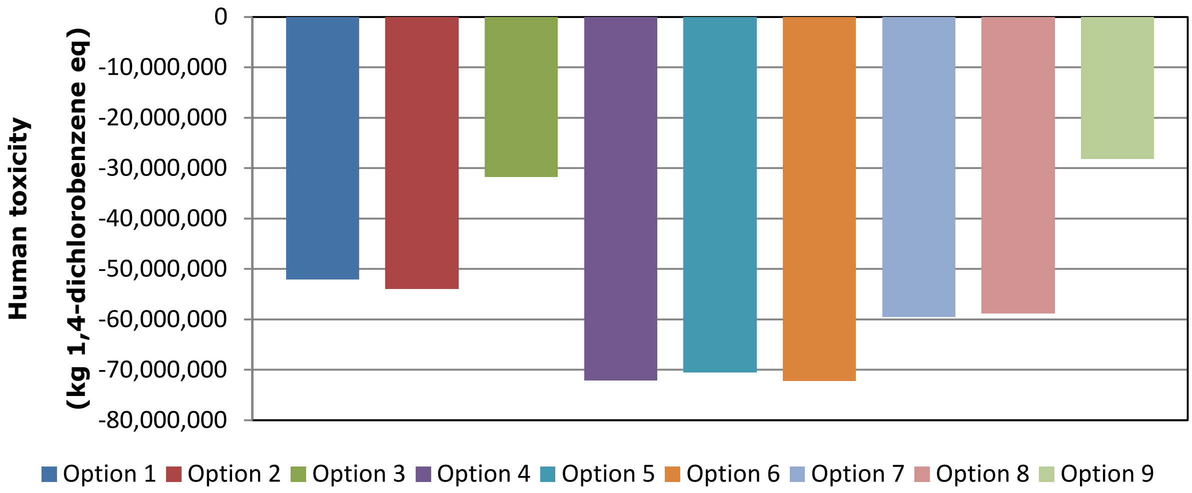


Figure 16 – Human toxicity results

Options 1 and 2 have an environmental benefit due to the recycling of materials and the production of power and subsequent offset from avoidance of fossil fuels. Emissions from the treatment and transportation of the waste offset this benefit somewhat. Option 3 has a lower environmental benefit due to the additional vehicle emissions produced in transporting the waste out of county. Option 9 performed very similarly to Option 3, with a slight reduction in environmental benefit due to the impact of compost use. The autoclave options (4 to 6) performed best due to the recyclates offsetting the production of virgin materials. The MBT options (7 and 8) performed better than Options 1 and 2 due to the recylates extracted.

The options have been scored based on their deviation from the mean, as summarised within Table 16 below. Due to the significant variation within the results the scoring boundaries were scaled so that all options fell within the bounds zero to ten.

Table 16 – Human toxicity assessment scores	
Option	**Score**
1. Mercia EnviRecover Facility (Power only)	5
2. Mercia EnviRecover Facility (CHP)	5
3. Out of County EfW	3
4. 1 site Autoclave (Fibre recycled as fibreboard)	7
5. 1 site Autoclave (Fibre landfilled)	6
6. 2 site Autoclave (Fibre recycled as fibreboard)	7
7. 2 site MBT with on-site combustion of the RDF	5
8. 2 site MBT with out of county combustion of the RDF	5
9. Out of County EfW with food waste AD	3

5.4 Freshwater aquatic ecotoxicity

The freshwater aquatic ecotoxicity results have been obtained from the WRATE model. These are shown graphically within Figure 17. A negative value indicates an environmental benefit whereas a positive value indicates an environmental burden.

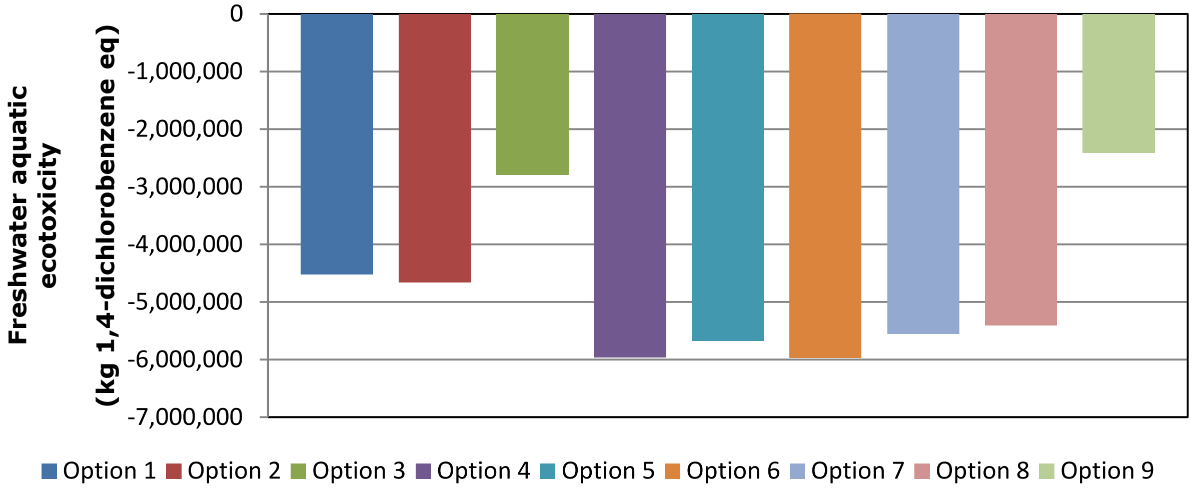


Figure 17 – Freshwater aquatic ecotoxicity results

All options showed an environmental benefit, but the options where significant materials are recycled (4 to 8) performed the best. Options 3 and 9 did not perform as well as the other EfW options due to the tonnage of material directly landfilled.

The options have been scored based on their deviation from the mean, as summarised within Table 17 below.

Table 17 – Freshwater aquatic ecotoxicity assessment scores	
Option	**Score**
1. Mercia EnviRecover Facility (Power only)	5
2. Mercia EnviRecover Facility (CHP)	5
3. Out of County EfW	3
4. 1 site Autoclave (Fibre recycled as fibreboard)	6
5. 1 site Autoclave (Fibre landfilled)	6
6. 2 site Autoclave (Fibre recycled as fibreboard)	6
7. 2 site MBT with on-site combustion of the RDF	6
8. 2 site MBT with out of county combustion of the RDF	6
9. Out of County EfW with food waste AD	3

5.5 Acidification

The acidification results have been obtained from the WRATE model. These are shown graphically within Figure 18. A negative value indicates an environmental benefit whereas a positive value indicates an environmental burden.

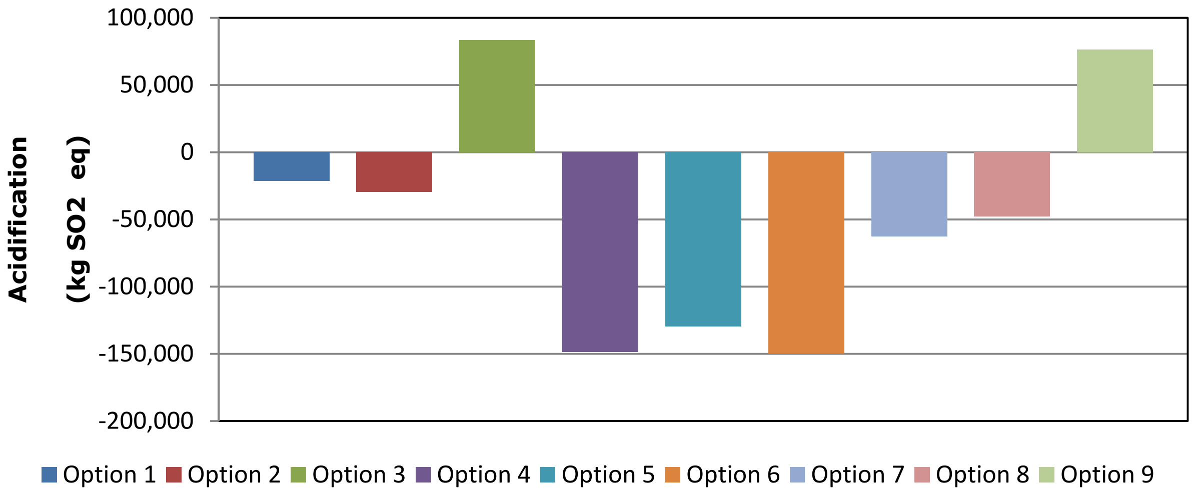


Figure 18 – Acidification results

The bespoke EfW options (1 and 2) have a similar performance, showing an environmental benefit. Option 3 has a significant environmental burden when compared to options 1 and 2. This is due to acid gas emissions from the modelled EfWs. The bespoke process created to represent the Hartlebury EfW has been based on the default Chineham process. This process uses measured data to calculated the facility emissions. The default processes for Dundee and Coventry do not used measured data, and thus the burden caused by acid gas emissions from these facilities is higher. However, the Chineham process is not appropriate for use as a default process to represent the out of county EfWs in this option due to differences in size and technology.

Option 9 has a smaller environmental burden than Option 3 due to the reduced tonnage of waste processed at the EfWs. The autoclave options (4 to 6) extract a large quantity of recyclables which offsets burdens associated with the production of virgin materials and hence have a high environmental benefit. Option 7 has a very small benefit due to the recyclables negating the burden of the thermal treatment. Option 8 has a small burden due to the additional vehicle transport in comparison with Option 7.

The options have been scored based on their deviation from the mean, as summarised within Table 18 below. Due to the significant variation within the results the scoring boundaries were scaled so that all options fell within the bounds zero to ten.

Table 18 – Acidification assessment scores

Option	Score
1. Mercia EnviRecover Facility (Power only)	2
2. Mercia EnviRecover Facility (CHP)	3
3. Out of County EfW	0
4. 1 site Autoclave (Fibre recycled as fibreboard)	10
5. 1 site Autoclave (Fibre landfilled)	10
6. 2 site Autoclave (Fibre recycled as fibreboard)	10
7. 2 site MBT with on-site combustion of the RDF	7
8. 2 site MBT with out of county combustion of the RDF	5
9. Out of County EfW with food waste AD	0

5.6 Eutrophication

The eutrophication results have been obtained from the WRATE model. These are shown graphically within Figure 19. A negative value indicates an environmental benefit whereas a positive value indicates an environmental burden.

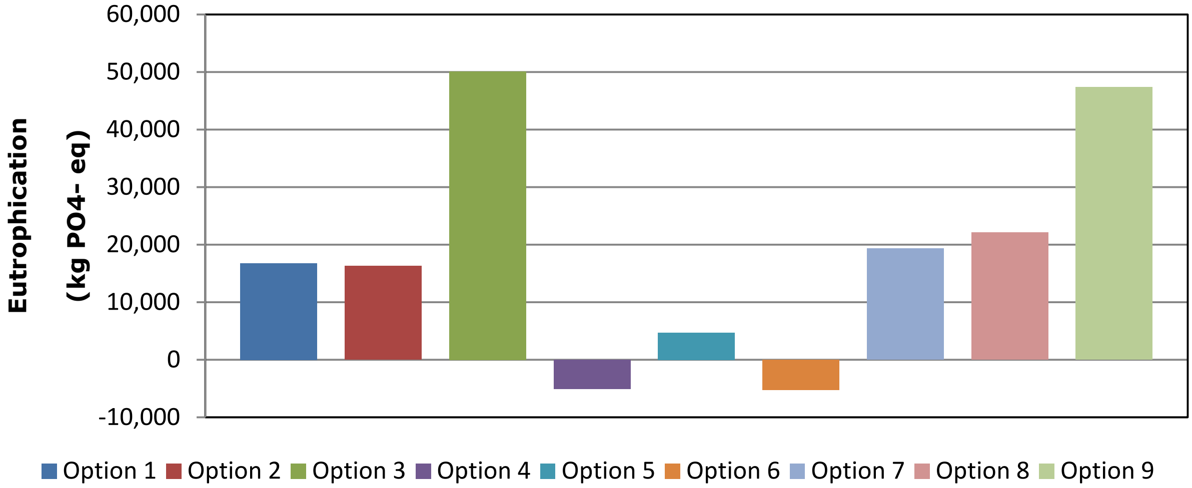


Figure 19 – Eutrophication results

The autoclave options with recycling (4 and 6) have an environmental benefit due to the recycling performance of the technology. Option 5 has a small environmental burden due to the amount of material sent to landfill. The recycling performance of the MBT options (7 and 8) is negated by the amount of rejects landfilled and treated within an EfW. These options therefore show an environmental burden. Options 1 and 2 show a slightly higher environmental burden than the MBT options due to the lack of front end recycling. Option 3 shows the highest environmental burden due to the amount of waste directly landfilled, with Option 9 showing a slightly lower environmental burden due to the diversion of waste from the EfW to the AD.

The options have been scored based on their deviation from the mean, as summarised within Table 19 below. Due to the significant variation within the results the scoring boundaries were scaled so that all options fell within the bounds zero to ten.

Table 19 – Eutrophication assessment scores

Option	Score
1. Mercia EnviRecover Facility (Power only)	5
2. Mercia EnviRecover Facility (CHP)	6
3. Out of County EfW	0
4. 1 site Autoclave (Fibre recycled as fibreboard)	10
5. 1 site Autoclave (Fibre landfilled)	9
6. 2 site Autoclave (Fibre recycled as fibreboard)	10
7. 2 site MBT with on-site combustion of the RDF	5
8. 2 site MBT with out of county combustion of the RDF	4
9. Out of County EfW with food waste AD	0

5.7 Capital cost

Table 20 below summarises the breakdown of estimated capital costs based on Fichtner's experience. As discussed in the capital cost assumptions, the cost of the heat export distribution system for Option 2 has not been included within this assessment. This is because the capital investment will vary significantly depending on the quantity and quality of the heat exported and also the end user location. Also the capital investment can be provided by the distribution network operator if the heat price is low. This has therefore been reflected within this assessment.

Development costs include the cost of planning and permitting, enabling works, grid connection and owner's engineer services.

It should be noted that these have been rounded and so the component costs may not sum exactly to the total given.

Table 20 – Estimated capital costs (£m)

	1	2	3	4	5	6	7	8	9
MBT	-	-	-	-	-	-	68	68	-
Autoclave	-	-	-	87	87	94	-	-	-
EfW	131	131	-	-	-	-	105	-	-

Table 20 – Estimated capital costs (£m)									
	1	2	3	4	5	6	7	8	9
AD	-	-	-	-	-	-	-	-	8
Development costs	4	4	-	3	3	5	7	5	1
Total	**135**	**135**	**0**	**91**	**91**	**99**	**179**	**73**	**9**

These estimated capital costs have been transferred into scenario scores based on the deviation from the mean. These scores are summarised in Table 21 below.

Table 21 – Capital cost assessment scores	
Option	Score
1. Mercia EnviRecover Facility (Power only)	2
2. Mercia EnviRecover Facility (CHP)	2
3. Out of County EfW	10
4. 1 site Autoclave (Fibre recycled as fibreboard)	5
5. 1 site Autoclave (Fibre landfilled)	5
6. 2 site Autoclave (Fibre recycled as fibreboard)	4
7. 2 site MBT with on-site combustion of the RDF	0
8. 2 site MBT with out of county combustion of the RDF	6
9. Out of County EfW with food waste AD	10

5.8 Operating cost

Table 22 below summarises the breakdown of estimated capital costs based on Fichtner's experience. Please note that these have been rounded and so the component costs may not sum exactly to the total given. The assumptions provided within section 4.4.3.2 have been used to estimate the operating costs.

Table 22 – Estimated annual operating costs (£m)									
	1	2	3	4	5	6	7	8	9
Transportation	-1.4	-1.4	-4.7	-2.0	-2.0	-1.9	-1.7	-3.3	-4.1
Maintenance	-3.4	-3.4	-	-2.3	-2.3	-2.4	-4.5	-1.8	-0.2
Product treatment[1]	-0.4	-0.4	-18	-2.1	-	-2.1	-0.2	-8.3	-16.3
Landfill (excl. Tax)	-1.2	-1.2	-1.3	-0.5	-2.6	-0.5	-1.6	-1.1	-1.1
Landfill Tax	-0.6	-0.6	-3.2	-1.3	-6.2	-1.3	-2.8	-2.6	-2.6

[1] This figure includes the recycling of bottom ash and fibre and the marketing of the RDF.

Table 22 – Estimated annual operating costs (£m)									
	1	2	3	4	5	6	7	8	9
Misc[2]	-3.0	-3.0	-	-2.	-2.4	-3.4	-4.2	-3.3	-0.5
Total Cost	**-10**	**-10**	**-23.2**	**-10.6**	**-15.5**	**11.6**	**-15.1**	**-20.4**	**-21.6**
Power Export	4.0	3.4	-	-	-	-	2.6	-	0.1
Heat Export	-	0.8	-	-	-	-	-	-	-
RHI	-	2.0	-	-	-	-	-	-	-
LECs	0.3	0.2	-	-	-	-	0.2	-	-
Recyclables	-	-	-	2.4	2.4	2.4	0.6	0.6	-
Total Revenue	**4.3**	**6.4**	**-**	**2.4**	**2.4**	**2.4**	**3.4**	**0.6**	**0.1**
Net Opex	**-5.7**	**-3.6**	**-23.2**	**-8.2**	**-13.1**	**-9.2**	**-11.7**	**-19.8**	**-21.5**

These estimated operating costs have been transferred into scenario scores based on the deviation from the mean. These scores are summarised in Table 23 below.

Table 23 – Operating cost assessment scores	
Option	**Score**
1. Mercia EnviRecover Facility (Power only)	8
2. Mercia EnviRecover Facility (CHP)	9
3. Out of County EfW	1
4. 1 site Autoclave (Fibre recycled as fibreboard)	7
5. 1 site Autoclave (Fibre landfilled)	5
6. 2 site Autoclave (Fibre recycled as fibreboard)	6
7. 2 site MBT with on-site combustion of the RDF	5
8. 2 site MBT with out of county combustion of the RDF	2
9. Out of County EfW with food waste AD	2

[2] This figure includes staffing, consumables, imported power, leases, overheads, rates, export/import network charges etc.

5.9 Reference facilities

The EfW based options, including the added AD option, score 10 due to multiple UK references of a similar size. The MBT options (7 and 8) both score 9 due to multiple UK references, but these are of a smaller capacity. Finally the Autoclave options (4 to 6) score 8 due to a single UK reference currently in operation.

Table 24 – Reference facility assessment scores

Option	Score
1. Mercia EnviRecover Facility (Power only)	10
2. Mercia EnviRecover Facility (CHP)	10
3. Out of County EfW	10
4. 1 site Autoclave (Fibre recycled as fibreboard)	8
5. 1 site Autoclave (Fibre landfilled)	8
6. 2 site Autoclave (Fibre recycled as fibreboard)	8
7. 2 site MBT with on-site combustion of the RDF	9
8. 2 site MBT with out of county combustion of the RDF	9
9. Out of County EfW with food waste AD	10

5.10 Planning risk

Axis (planning consultants) has considered the planning risk associated with each option and scored them accordingly. The scoring has been based on the following factors:

(1) Planning consents were granted for two Estech autoclave facilities at Hartlebury and Madley in 2004. These are for 100,000 tonnes per annum facilities. At that time Estech were in negotiation with the Councils over an involvement within the Municipal Waste PFI Contract. The Councils have subsequently formally (committee resolution) broken off negotiations with Estech (and their successors). These consents have now lapsed and so are not considered to benefit the autoclave options.

(2) Options with two sites (6, 7 and 8), necessitating two planning permissions, incur a greater risk than a single application.

(3) The out of county EfW option carries little direct planning risk as it is considered to be an existing facility, but does have 'additional' risk in terms of whether capacity is available.

(4) Inclusion of a heat export is considered to marginally reduce the planning risk.

(5) From a national perspective, we are aware that over the past four years very few autoclave planning permissions have been granted. Conversely, the number of EfW and MBT consents is considerable.

(6) We see little material difference in planning risk between two site MBT with off-site thermal treatment (Option 8) and two site autoclaves (Option 6). Both would comprise large 'sheds' of a similar size, producing a 'fibre/compost like material'.

This is summarised in Table 25 below.

Table 25 – Planning risk assessment scores	
Option	**Score**
1. Mercia EnviRecover Facility (Power only)	5
2. Mercia EnviRecover Facility (CHP)	6
3. Out of County EfW	10
4. 1 site Autoclave (Fibre recycled as fibreboard)	6
5. 1 site Autoclave (Fibre landfilled)	6
6. 2 site Autoclave (Fibre recycled as fibreboard)	5
7. 2 site MBT with on-site combustion of the RDF	2
8. 2 site MBT with out of county combustion of the RDF	5
9. Out of County EfW with food waste AD	8

5.11 BMW diversion from landfill

With the exception of Option 5, where the fibre is landfilled, all of the options achieved a high BMW diversion. The scores obtained by the various options are summarised in Table 26 below.

Table 26 – BMW diversion from landfill assessment scores	
Option	**Score**
1. Mercia EnviRecover Facility (Power only)	10
2. Mercia EnviRecover Facility (CHP)	10
3. Out of County EfW	7
4. 1 site Autoclave (Fibre recycled as fibreboard)	9
5. 1 site Autoclave (Fibre landfilled)	5
6. 2 site Autoclave (Fibre recycled as fibreboard)	9
7. 2 site MBT with on-site combustion of the RDF	8
8. 2 site MBT with out of county combustion of the RDF	8
9. Out of County EfW with food waste AD	7

5.12 Waste composition flexibility

The waste composition flexibility assessment has been conducted based on the criteria detailed in section 4.2.6.

The Mercia EnviRecover facility options (1 and 2) score 9 due to the technology's ability to accommodate wide changes in waste composition with minor performance reduction. Option 3, the out of county EfW, scores an 8. This is because the contract with the third party is likely to have some limits on net calorific value (NCV), therefore only small changes in composition and thus NCV would be acceptable. The out of county EfW with an added food AD scores a 7. This is because the AD process will be sensitive to changes in input waste composition, with substantial decreases in performance possible.

The autoclave and MBT options all score 7. This is due to the technology's ability to accommodate wide changes in composition but will significant loss of performance. Both technologies are able to accommodate a wide range of input compositions. However the recycling performance and quality of the product (fibre/RDF) can be significantly affected by variations in composition.

Table 27 – Waste composition flexibility assessment scores

Option	Score
1. Mercia EnviRecover Facility (Power only)	9
2. Mercia EnviRecover Facility (CHP)	9
3. Out of County EfW	8
4. 1 site Autoclave (Fibre recycled as fibreboard)	7
5. 1 site Autoclave (Fibre landfilled)	7
6. 2 site Autoclave (Fibre recycled as fibreboard)	7
7. 2 site MBT with on-site combustion of the RDF	7
8. 2 site MBT with out of county combustion of the RDF	7
9. Out of County EfW with food waste AD	7

5.13 Waste tonnage flexibility

Options 1 and 2 scored an 8 overall; 4 for tonnage increase flexibility and 4 for tonnage decrease flexibility. This is because the technology is able to accept quite large changes in waste tonnage as the increased/lost tonnage can be offset by a corresponding reduction/increase in third party wastes.

Option 3 scored a 4 overall; 1 for tonnage increase flexibility and 3 for tonnage decrease flexibility. This is because a contract with a third party facility is likely to have a minimum and maximum tonnage. Within these bounds the third party facility would be able to accommodate changes. If the tonnage increases above the maximum then the facility may not have sufficient capacity and so this scores low. The facility would be more flexible to tonnage decreases as the spare capacity could be filled with third party wastes. Option 9 has the same flexibility scores as Option 3. The majority of the waste in Option 9 is treated in the same way as in Option 3, so it has the same limitations to changes in tonnage.

Options 4, 5 and 6 scored 3 overall; 2 for tonnage increase flexibility and 1 for tonnage decrease flexibility. Although autoclaves are modular and additional units can be installed if tonnages increase, facilities would not be designed for spare capacity. Therefore small increases in tonnage would require new units. Autoclaves are more sensitive to waste composition than EfWs and so offsetting reduced tonnages with third party wastes is not easily achievable.

Option 7 scored a 7 overall; 3 for tonnage increase flexibility and 4 for tonnage decrease flexibility. The combination of MBT and EfW would score almost the same as options 1 and 2. This option has been scored down for flexibility to tonnage increases as the MBT may need additional modules for small tonnage increases.

Option 8 scored a 4 overall; 1 for tonnage increase flexibility and 3 for tonnage decrease flexibility. Although the MBT process is able to accommodate changes in tonnage the RDF is still subject to offtake contracts and so scores the same as the out of county EfW option.

Table 28 – Waste tonnage flexibility assessment scores	
Option	**Score**
1. Mercia EnviRecover Facility (Power only)	8
2. Mercia EnviRecover Facility (CHP)	8
3. Out of County EfW	4
4. 1 site Autoclave (Fibre recycled as fibreboard)	3
5. 1 site Autoclave (Fibre landfilled)	3
6. 2 site Autoclave (Fibre recycled as fibreboard)	3
7. 2 site MBT with on-site combustion of the RDF	7
8. 2 site MBT with out of county combustion of the RDF	4
9. Out of County EfW with food waste AD	4

5.14 End product liability

Options 1, 2, 5 and 7 scored highly as the outputs either have established markets or only generate a small quantity of material with a high liability. Options 4 and 6 did not score well due to the lack of established recycling markets for the fibre. Option 8 scored the lowest due to the large tonnage of RDF produced which requires a market.

Table 29 – End product liability assessment scores	
Option	**Score**
1. Mercia EnviRecover Facility (Power only)	8
2. Mercia EnviRecover Facility (CHP)	8
3. Out of County EfW	4
4. 1 site Autoclave (Fibre recycled as fibreboard)	2
5. 1 site Autoclave (Fibre landfilled)	8
6. 2 site Autoclave (Fibre recycled as fibreboard)	2
7. 2 site MBT with on-site combustion of the RDF	8
8. 2 site MBT with out of county combustion of the RDF	1
9. Out of County EfW with food waste AD	4

5.15 Transport

The total distance travelled by vehicles transporting waste to treatment and transporting outputs from the treatment site to the final destination are summarised in Table 30 below.

Table 30 – Transport distances ('000 km)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Total distance to treatment site(s)	925	925	4,200	925	925	806	806	806	3,626
Total distance between site(s)							244	1,840	
Total distance following treatment	356	356	215	892	892	892	466	457	210
Total	**1,281**	**1,281**	**4,415**	**1,817**	**1,817**	**1,698**	**1,515**	**3,102**	**3,836**

These transport distances have been transferred into scenario scores based on the deviation from the mean. These scores are summarised in Table 31 below.

Table 31 – Transport assessment scores	
Option	**Score**
1. Mercia EnviRecover Facility (Power only)	7
2. Mercia EnviRecover Facility (CHP)	7
3. Out of County EfW	0
4. 1 site Autoclave (Fibre recycled as fibreboard)	6
5. 1 site Autoclave (Fibre landfilled)	6
6. 2 site Autoclave (Fibre recycled as fibreboard)	6
7. 2 site MBT with on-site combustion of the RDF	7
8. 2 site MBT with out of county combustion of the RDF	3
9. Out of County EfW with food waste AD	2

5.16 Overall scores

Table 32 below summarises the results of the options appraisal. This also calculates the overall score for each option based on the category weightings detailed in section 4.3. Lower overall scores indicate options which fail to meet the Authorities' objectives, whereas higher overall scores indicate scenarios which meet the Authorities' objectives. The scenarios are then ranked based on the overall score.

Cells highlighted yellow indicate the highest score achieved for each assessment category.

The highest scoring option is Option 2, the Mercia EnviRecover facility with CHP. This achieves the highest score, either alone or equal with another option, in nine of the fifteen assessment criteria. Option 1 (the Mercia EnviRecover facility) closely follows in second., There is a clear gap in scores (24 points) to the 3rd placeOption 4 (1 site autoclave with fibre to recycling). This however assumes that the fibre produced by the autoclave can be recycled into fibreboard. If instead the fibre is landfilled (Option 5) the overall score falls by an additional 27 points, or about 10%. This reflects the more likely position, given the lack of a proven market for fibre. The MBT based options come 6th and 7th with a significant difference to the scores obtained by the EfW with CHP. The out of county solution came last; although the highest scoring in planning risk and capital cost, the high environmental impact, high transportation impact and high operating costs mean that the option does not score well. The out of county option with an AD facility for source segregated food waste tied with the standard out of county option. While the operating costs and impacts of transport were improved with the inclusion of an in county AD facility, these were offset by reductions is score for planning risk, waste composition flexibility and abiotic resource depletion.

Table 32 – Options appraisal summary and overall scores

Option	Weighting	1	2	3	4	5	6	7	8	9
Abiotic Resource Depletion	3	7	8	4	4	4	4	5	5	3
Global warming potential	3	10	10	0	10	4	10	3	1	0
Human toxicity	1	5	5	3	7	6	7	6	5	3
Freshwater aquatic ecotoxicity	1	5	5	3	6	6	6	6	6	3
Acidification	2	2	3	0	10	10	10	7	5	0
Eutrophication	2	5	6	0	10	9	10	5	4	0
Capital cost	4	2	2	10	5	5	4	0	6	10
Operating cost	4	8	9	1	7	5	6	5	2	2
Reference facilities	4	10	10	10	8	8	8	9	9	10
Planning risk	3	5	6	10	6	6	5	2	5	8
BMW diversion	4	10	10	7	9	5	9	8	8	7
Waste composition flexibility	3	9	9	8	7	7	7	7	7	7
Waste tonnage flexibility	3	8	8	4	3	3	3	7	4	4
End product liability	3	8	8	4	2	8	2	8	1	4
Transport	4	7	7	0	6	6	6	7	3	2
Overall Score		**313**	**327**	**208**	**289**	**262**	**278**	**247**	**210**	**208**
Ranking		2	1	8 (tie)	3	5	4	6	7	8 (tie)

5.17 Runcorn Efficiency Sensitivity

In addition to the 9 cases run in the options assessment, an additional sensitivity was run on Option 8. This sensitivity has been defined as Option 8a. The purpose of this sensitivity was to examine the impact on the overall score of the Option if the net electrical efficiency of the Runcorn EfW were increased. While the Runcorn facility is not yet operational, it is a larger facility than the one proposed for Hartlebury. Therefore, it is possible that the net electrical efficiency will be higher than that assumed in the bespoke process for the Hartlebury EfW.

The sensitivity run examined an increase in net electrical efficiency from 22% to 25.2%. The increased Runcorn efficiency is based on Fichtner experience with larger EfW facilities. The overall score results are shown in Table 33 below.

Table 33 – Option 8 sensitivity summary and overall scores

Option	Weighting	8	8a
Abiotic Resource Depletion	3	5	6
Global warming potential	3	1	6
Human toxicity	1	5	5
Freshwater aquatic ecotoxicity	1	6	6
Acidification	2	5	6
Eutrophication	2	4	4
Capital cost	4	6	6
Operating cost	4	2	2
Reference facilities	4	9	9
Planning risk	3	5	5
BMW diversion	4	8	8
Waste composition flexibility	3	7	7
Waste tonnage flexibility	3	4	4
End product liability	3	1	1
Transport	4	3	3
Overall Score		**210**	**230**

The results of Option 8a show an increase in overall score when compared to Option 8. This increase is due to improved performance in terms of global warming potential, abiotic resource depletion and acidification compared to the lower efficiency baseline.

The overall score of Option 8a is 20 points higher than that of Option 8. In the overall scoring, Option 8 finishes 7th, but it is 37 points behind 6th place. Therefore, this increase in efficiency would not affect the overall ranking of option 8.

Appendix A – WRATE Allocation Tables

The allocation tables below summarise the changes made to the Chineham process' allocation tables.

A.1 Mercia EnviRecover EfW (Power only)

Headline Values		
Headline Values	**Allocation Rule**	**Comment**
Energy Recovered [MJ]	=[USER_TOTAL.NET_CV]*0.22	Energy recovered is assumed to equal energy output. The allocation rule has been adjusted to reflect a net electrical efficiency of 22%.

Construction Material Inputs		
Material	**Allocation Rule**	**Comment**
Copper	=([USER_PROCESS_PARAM.CAPACITY]/[PROCESS_PARAM.MAX_CAP_MASS])*([USER_WASTE_FRACTIONS_TOTAL]/[USER_PROCESS_PARAM.CAPACITY])*(1/[PROCESS_PARAM.LIFESPAN_YEARS])*[CONSTR_INPUTS.CEMENT.UNDEFINED]	This allocation rule has been updated to correct a known error in the WRATE v2 Chineham default process.

The remaining items in Construction Materials Inputs, Maintenance Material Inputs and Maintenance Material Outputs are not changed. The default process uses scaling to ensure the assumptions from Chineham are modified as appropriate to the new throughput.

Operational Material Inputs					
Material	**Sub process**	**Quantity (kg)**	**Allocation Rule**	**Background**	**Comment**
Lime	Gas Cleaning	3,600,000	=18.0*[USER_WASTE_FRACTIONS_TOTAL]/1000	lime, hydrated, packed, at plant	Consumption of 18 kg/tonne waste
Activated Carbon	Gas Cleaning	100,000	=0.5*[USER_WASTE_FRACTIONS_TOTAL]/1000	Carbon black, at plant	Consumption of 0.5 kg/tonne waste
Anhydrous Ammonia	Gas Cleaning	275,000	=5.5*0.25*[USER_WASTE_FRACTIONS_TOTAL]/1000	ammonium nitrate, as N, at regional storehouse	Consumption of 5.5 kg of 25% solution/tonne waste
Urea Powder	Gas Cleaning	0	=[PROC_MATERIAL_INPUTS.UREA_POWDER.GAS_CLEAN]	Urea ammonium nitrate, as N, at regional storehouse	Removed as the proposed process used ammonia rather than urea.

Operational Water Inputs		
Water	**Allocation Rule**	**Comment**
Mains Water	=([USER_WASTE_FRACTIONS_TOTAL]/[PROCESS_PARAM.CAPACITY])*[PROC_WATER_INPUTS.MAINS.PROCESS_WATER]	This allocation rule was amended to correct a known error in the WRATE v2 default Chineham process.

Energy Inputs				
Energy	**Sub process**	**Quantity (MJ)**	**Quality**	**Comment**
Electricity Grid	Process	1,835,280	Estimated	Fichtner estimated electrical energy inputs when plant is non-operational, and assumed low level continuous import.

Energy Production		
Energy	**Allocation Rule**	**Comment**
Electricity Grid	=[USER_TOTAL.NET_CV]*0.22	Based on 22% net electrical efficiency

Process Waste Output		
Product	**Allocation Rule**	**Comment**
Air Pollution Control Residue APC 1	=40.0*[USER_WASTE_FRACTIONS_TOTAL]/1000	Allocation rule adjusted to reflect production of 40 kg/tonne of waste treated

The majority of the process emissions are scaled from the original Chineham data by throughput. The CO_2 and CO emissions have been edited based on a combustion calculation performed on the input waste, as the default WRATE process does not balance in terms of carbon.

Process Emissions						
Burden	**Sub process**	**Destination**	**Quantity (kg)**	**Quality**	**Background**	**Comment**
Carbon dioxide - Biogenic	Process	Air	106,403,210	Estimated	Carbon dioxide, biogenic/air/kg	Based on combustion calculation
Carbon dioxide, fossil	Process	Air	59,576,257	Estimated	Carbon dioxide, fossil/air/kg	Based on combustion calculation
Carbon monoxide (biogenic)	Process	Air	35,515	Estimated	Carbon Monoxide (CO) (fossil)/air/kg	Based on combustion calculation
Carbon monoxide (fossil)	Process	Air	19,885	Estimated	Carbon Monoxide (CO)(biogenic)/air/kg	Based on combustion calculation

A.2 Mercia EnviRecover EfW (CHP)

The CHP EfW process model was produced as a further extension of the EfW model detailed above. As the same fuel, thermal capacity site etc. would be used in the event the facility also exported heat only limited changes were required to allow the CHP process to be modelled. In this case only the following fields of the allocation table were edited:

Headline Values		
Headline Values	**Allocation Rule**	**Comment**
Energy Recovered [MJ]	=[USER_TOTAL.NET_CV]*0.36	Energy recovered is assumed to equal energy output, includes heat export. The allocation rule has been adjusted to reflect a net overall efficiency of 36%.

Energy Production		
Energy	**Allocation Rule**	**Comment**
Electricity Grid	=[USER_TOTAL.NET_CV]*0.19	Based on 19% net electrical efficiency
External Heat	=[USER_TOTAL.NET_CV]*0.17	Based on 17% net heat efficiency

A.3 Mercia EnviRecover EfW (with MBT)

The EfW process used in the Options included MBT is identical to that in the EfW only option except for the carbon balance. As the input waste is different because of the MBT processes, the carbon balance was adjusted to account for this change in input waste.

Process Emissions						
Burden	**Sub process**	**Destination**	**Quantity (kg)**	**Quality**	**Background**	**Comment**
Carbon dioxide - Biogenic	Process	Air	77,090,397	Estimated	Carbon dioxide, biogenic/air/kg	Based on combustion calculation

Process Emissions						
Burden	**Sub process**	**Destination**	**Quantity (kg)**	**Quality**	**Background**	**Comment**
Carbon dioxide, fossil	Process	Air	47,502,795	Estimated	Carbon dioxide, fossil/air/kg	Based on combustion calculation
Carbon monoxide (biogenic)	Process	Air	15,779	Estimated	Carbon Monoxide (CO) (fossil)/air/kg	Based on combustion calculation
Carbon monoxide (fossil)	Process	Air	9,723	Estimated	Carbon Monoxide (CO)(biogenic)/air/kg	Based on combustion calculation

Appendix B – Transport Assumptions

Default route compositions used for each vehicle type			
Vehicle Type	**Route Composition (%)**		
	Urban	**Rural**	**Motorway**
RCV	75.8	22.4	1.8
Front End Loader	23.3	51.9	24.8
Intermodal	7.9	42.9	49.2
Ro-Ro	23.3	51.9	24.8

Transport distances and tonnages common to Options 1, 2, 4 and 5						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Commercial Arisings	Hartlebury	C&I Waste	25	29,080	Front End Loader	The distance was selected as it was assumed sufficient C&I could be sourced within the county (EA default County level distance). The vehicle was selected as it is typical for this type of collection and delivery.
Wyre Forest	Hartlebury	MSW	8	26,121	RCV	These distances are based on the assumed waste arising location and their distance from Hartlebury. This vehicle was selected as it is typical for this type of collection and delivery.
Bromsgrove (Direct)	Hartlebury	MSW	18	5,090	RCV	
Wychavon North (Direct)	Hartlebury	MSW	10	7,612	RCV	
Worcester City	Hartlebury	MSW	18	20,198	RCV	
Malvern Hills (Direct)	Hartlebury	MSW	35	1,529	RCV	

Transport distances and tonnages common to Options 1, 2, 4 and 5						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Rotherwas WTS	Hartlebury	MSW	64	28,383	Intermodal	These distances are based on the WTS distance from Hartlebury. This vehicle was selected as it represents efficient bulk transport of MSW.
Leominster WTS	Hartlebury	MSW	52	13,918	Intermodal	
Malvern Hills	Leominster WTS	MSW	15	1,529	RCV	This distance is based on the distance to the WTS from the assumed point of arisings. This vehicle was selected as it is typical of vehicles used for this type of kerbside waste collection.
Redditch WTS	Hartlebury	MSW	29	33,005	Intermodal	This distance is based on the WTS distance from Hartlebury. This vehicle was selected as represents efficient bulk transport of MSW.
Bromsgrove	Redditch WTS	MSW	15	15,271	RCV	These distances are based on the assumed waste arising location and their distance from each WTS. This vehicle was selected as it is typical for this type of collection and delivery.
Wychavon North	HML WTS	MSW	24	6,190	RCV	
Wychavon South	HML WTS	MSW	8	16,646	RCV	
Malvern Hills	HML WTS	MSW	27	12,228	RCV	
HML WTS	Hartlebury	MSW	32	35,064	Intermodal	This distance is based on the WTS distance from Hartlebury. This vehicle was selected as it represents efficient bulk transport of MSW.

Additional transport distances and tonnages used in Option 1						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Hartlebury EfW	Landfill	APC residue	52	8,000	Intermodal	This distance is that of the route between Hartlebury and the Bishop's Cleeve Landfill. This vehicle has been selected as it is the closest match to the parameters of the tanker which would be used to remove the residue.
Hartlebury EfW	IBA Recycling	IBA	64	40,157	Intermodal	This distance is that of the route between Hartlebury and the Castle Bromwich IBA recycling facility. This vehicle has been selected as it the best representation of the bulk transport of ash.
Hartlebury EfW	Ferrous Recycling	Ferrous metals	25	2,258	Intermodal	The distance was selected as it was assumed a ferrous reprocessor could be found within the county (EA default County level distance). This vehicle has been selected as it the best representation of the bulk transport of metals for recycling.

Additional transport distances and tonnages used in Option 2						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Hartlebury CHP EfW	Landfill	APC residue	52	8,000	Intermodal	This distance is that of the route between Hartlebury and the Bishop's Cleeve Landfill. This vehicle has been selected as it is the closest match to the parameters of the tanker which would be used to remove the residue.
Hartlebury CHP EfW	IBA Recycling	IBA	64	40,157	Intermodal	This distance is that of the route between Hartlebury and the Castle Bromwich IBA recycling facility. This vehicle has been selected as it the best representation of the bulk transport of ash.

Additional transport distances and tonnages used in Option 2						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Hartlebury EfW	Ferrous Recycling	Ferrous metals	25	2,258	Intermodal	The distance was selected as it was assumed a ferrous reprocessor could be found within the county (EA default County level distance). This vehicle has been selected as it the best representation of the bulk transport of metals for recycling.

Additional transport distances and tonnages used in Option 4						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Hartlebury Autoclave	Fibre Recycling	Fibre	25	68,453	RO-RO	This distance has been selected for all these options as it has been assumed that the necessary recycling and landfill facilities would be available within the county. (25 km is the EA approved distance to assume on this level of transportation). Typically these materials would be loaded into skips/containers so RO-RO vehicles best represent the transport which would be used.
Hartlebury Autoclave	Ferrous Recycling	Ferrous Metal	25	4,003	RO-RO	
Hartlebury Autoclave	Non-Ferrous Recycling	Non-Ferrous Metal	25	1,242	RO-RO	
Hartlebury Autoclave	Dense Plastic Recycling	Dense Plastics	25	12,109	RO-RO	
Hartlebury Autoclave	Glass Recycling	Glass	25	6,767	RO-RO	
Hartlebury Autoclave	Plastic Film Recycling	Plastic Film	25	14,052	RO-RO	
Hartlebury Autoclave	Landfill	Reject	25	17,691	RO-RO	

Additional transport distances and tonnages used in Option 5						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Hartlebury Autoclave	Landfill	Fibre	25	68,453	RO-RO	This distance has been selected for all these options as it has been assumed that the necessary recycling and landfill facilities would be available within the county. (25 km is the EA approved distance to assume on this level of transportation). Typically these materials would be loaded into skips/containers so RO-RO vehicles best represent the transport which would be used.
Hartlebury Autoclave	Ferrous Recycling	Ferrous Metal	25	4,003	RO-RO	
Hartlebury Autoclave	Non-Ferrous Recycling	Non-Ferrous Metal	25	1,242	RO-RO	
Hartlebury Autoclave	Dense Plastic Recycling	Dense Plastics	25	12,109	RO-RO	This distance has been selected for all these options as it has been assumed that the necessary recycling and landfill facilities would be available within the county. (25 km is the EA approved distance to assume on this level of transportation). Typically these materials would be loaded into skips/containers so RO-RO vehicles best represent the transport which would be used.
Hartlebury Autoclave	Glass Recycling	Glass	25	6,767	RO-RO	
Hartlebury Autoclave	Plastic Film Recycling	Plastic Film	25	14,052	RO-RO	
Hartlebury Autoclave	Landfill	Reject	25	17,691	RO-RO	

Transport distances and tonnages used in Option 3						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
C&I	Coventry	C&I Waste	25	29,080	Front End Loader	The distance was selected as it was assumed sufficient C&I could be sourced within the county (EA default County level distance). The vehicle was selected as it is typical for this type of collection and delivery.
Wyre Forest	Hartlebury Landfill	MSW	8	26,172	RCV	This is the distance between the assumed centre of arisings and the Hartlebury landfill. The vehicle was chosen as it is typical for kerbside collection.

Transport distances and tonnages used in Option 3						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Bromsgrove	Coventry	MSW	59	17,571	RCV	These are the distances between the assumed centre of arisings and the Coventry EfW. The vehicle was chosen as it is typical for kerbside collection.
Reddtch	Coventry	MSW	54	17,734	RCV	
Bromsgrove	HML Landfill	MSW	30	2,790	RCV	These distances are those between the centre of arisings in each WCA and the HML landfill. The vehicle selection is based on typical collection vehicles.
Wychavon North	HML Landfill	MSW	24	5,179	RCV	
Wychavon South	HML Landfill	MSW	8	5,710	RCV	
Malvern Hills	HML Landfill	MSW	27	4,662	RCV	
Worcester City	Allington EfW	MSW	287	20,198	RCV	This distance is that between the centre of arisings and the Allington EfW. The vehicle selection is based on typical collection vehicles.
Malvern Hills	Leominster WTS	MSW	40	10,623	RCV	This distance is that between the centre of arisings and the WTS. The vehicle selection is based on typical collection vehicles.
Wychavon South	Allington EfW	MSW	261	10,936	RCV	These distances are those between the centre of arisings in each WCA and the Allington EfW. The vehicle selection is based on typical collection vehicles.
Wychavon North	Allington EfW	MSW	272	8,523	RCV	
Leominster WTS	Allington EfW	MSW	330	39,058	Intermodal	These distances are those between the WTS facilities and the Allington EfW. The vehicle selection is the most representative of efficient bulk transport.
Rotherwas WTS	Allington EfW	MSW	293	12,389	Intermodal	
Coventry	Landfill	APC residue	50	2,536	Intermodal	This distance has been assumed to represent the assumption that APC disposal would be available within the region. (50 km is the EA approved standard for regional deliveries). This vehicle has been selected as it is the closest match to the parameters of the tanker which would be used to remove the residue.

Transport distances and tonnages used in Option 3						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Coventry	IBA Recycling	IBA	33	12,574	Intermodal	This distance has been assumed to represent the transport of IBA from the Coventry EfW to the Castle Bromwich bottom ash processor. This vehicle has been selected as it the best representation of the bulk transport of ash.
Coventry	Ferrous Recycling	Ferrous Metal	25	900	RO-RO	This distance has been selected as it is assumed that metals recycling will be available within the county. Typically the recyclable metals will be collected in skips/containers and transported to recycling facilities on RO-RO vehicles.
Allington EfW	Hazardous Landfill	APC Residue	50	3,672	Intermodal	This distance has been selected as it is assumed that hazardous landfill space will be available within the region. This vehicle selection best represents the tankers used to transport APC residue.
Allington EfW	Landfill	Rejects	25	6,550	Intermodal	This distance has been selected as it is assumed that landfill space will be available within the county. This vehicle selection represents the efficient bulk transport of rejects to landfill.
Allington EfW	Metals Recycling	Metals	25	981	RO-RO	This distance has been selected as it is assumed that metals recycling will be available within the county. Typically the recyclable metals will be collected in skips/containers and transported to recycling facilities on RO-RO vehicles.
Allington EfW	IBA Recycling	IBA	50	18,447	Intermodal	This distance has been selected as it is assumed that an IBA recycling facility is available within the region. This vehicle selection best represents the bulk vehicles used to transport IBA.

Transport distances and tonnages common to Options 6, 7 and 8						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
C&I (Madley)	Madley Airfield	C&I Waste	25	9,900	Front End Loader	The distance was selected as it was assumed sufficient C&I could be sourced within the county (EA default County level distance). The vehicle was selected as it is typical for this type of collection and delivery
C&I (Hartlebury)	Hartlebury	C&I Waste	25	19,180	Front End Loader	
Wyre Forest	Hartlebury	MSW	8	26,121	RCV	These distances are based on the assumed waste arising location and their distance from Hartlebury. This vehicle was selected as it is typical for this type of collection and delivery
Bromsgrove (Direct)	Hartlebury	MSW	18	5,090	RCV	
Wychavon North (Direct)	Hartlebury	MSW	9	7,612	RCV	
Worcester City	Hartlebury	MSW	17	20,198	RCV	
Malvern Hills (Direct)	Hartlebury	MSW	28	1,529	RCV	
Rotherwas WTS	Madley Airfield	MSW	14	28,385	Intermodal	These distances are based on the WTS distances from Madley. This vehicle was selected as represents efficient bulk transport of MSW.
Leominster WTS	Madley Airfield	MSW	33	13,918	Intermodal	
Malvern Hills	Leominster WTS	MSW	15	1,529	RCV	This distance is based on the assumed waste arising location and the distance from the WTS. This vehicle was selected as it is typical for this type of collection and delivery.
Redditch WTS	Hartlebury	MSW	29	33,005	Intermodal	This distance is based on the WTS distance from Hartlebury. This vehicle was selected as represents efficient bulk transport of MSW.

Transport distances and tonnages common to Options 6, 7 and 8						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Bromsgrove	Redditch WTS	MSW	15	15,271	RCV	These distances are based on the assumed waste arising location and their distance from each WTS. This vehicle was selected as it is typical for this type of collection and delivery.
Wychavon North	HML WTS	MSW	24	6,190	RCV	
Wychavon South	HML WTS	MSW	8	16,646	RCV	
Malvern Hills	HML WTS	MSW	27	12,228	RCV	
HML WTS	Hartlebury	MSW	32	21,265	Intermodal	These distances are based on the WTS distances from Hartlebury. This vehicle was selected as represents efficient bulk transport of MSW.
HML WTS	Madley Airfield	MSW	79	13,799	Intermodal	

Additional transport distances and tonnages used in Option 6						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Madley Airfield	Fibre Recycling	Fibre	25	22,737	RO-RO	This distance has been selected for all these options as it has been assumed that the necessary recycling and landfill facilities would be available within the county. (25 km is the EA approved distance to assume on this level of transportation). Typically these materials would be loaded into skips/containers so RO-RO vehicles best represent the transport which would be used.
Madley Airfield	Ferrous Recycling	Ferrous Metal	25	1,326	RO-RO	
Madley Airfield	Non-Ferrous Recycling	Non-Ferrous Metal	25	409	RO-RO	
Madley Airfield	Dense Plastic Recycling	Dense Plastic	25	3,998	RO-RO	
Madley Airfield	Plastic Film Recycling	Plastic Film	25	4,639	RO-RO	
Madley Airfield	Glass Recycling	Glass	25	2,239	RO-RO	
Madley Airfield	Landfill	Reject Material	25	5,827	RO-RO	

Additional transport distances and tonnages used in Option 6

Start	Destination	Material	Distance (km)	Tonnage	Vehicle Type	Justification
Hartlebury	Fibre Recycling	Fibre	25	45,716	RO-RO	This distance has been selected for all these options as it has been assumed that the necessary recycling and landfill facilities would be available within the county. (25 km is the EA approved distance to assume on this level of transportation). Typically these materials would be loaded into skips/containers so RO-RO vehicles best represent the transport which would be used.
Hartlebury	Ferrous Recycling	Ferrous Metal	25	2,677	RO-RO	
Hartlebury	Non-Ferrous Recycling	Non-Ferrous Metal	25	832	RO-RO	
Hartlebury	Dense Plastic Recycling	Dense Plastic	25	8,111	RO-RO	
Hartlebury	Plastic Film Recycling	Plastic Film	25	9,413	RO-RO	
Hartlebury	Glass Film Recycling	Glass	25	4,528	RO-RO	
Hartlebury	Landfill	Reject Material	25	11,864	RO-RO	

Additional transport distances and tonnages used in Option 7

Start	Destination	Material	Distance (km)	Tonnage	Vehicle Type	Justification
Madley Airfield	Hartlebury EfW	RDF	70	30,413	Intermodal	This is the distance between Madley and Hartlebury. This material would typically be bulked for transport to a combustion facility; hence the intermodal vehicle has been selected.

Additional transport distances and tonnages used in Option 7						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Madley Airfield	Glass Recycling	Glass	25	2,497	RO-RO	This distance has been selected for all these options as it has been assumed that the necessary recycling and landfill facilities would be available within the county. (25 km is the EA approved distance to assume on this level of transportation). Typically these materials would be loaded into skips/containers so RO-RO vehicles best represent the transport which would be used.
Madley Airfield	Ferrous Recycling	Ferrous Metal	25	1,156	RO-RO	
Madley Airfield	Non-Ferrous Recycling	Non-Ferrous Metal	25	365	RO-RO	
Madley Airfield	Landfill	Reject Material	25	11,841	RO-RO	
Hartlebury	Glass Recycling	Glass	25	5,049	RO-RO	
Hartlebury	Ferrous Recycling	Ferrous Metal	25	2,335	RO-RO	This distance has been selected for all these options as it has been assumed that the necessary recycling and landfill facilities would be available within the county. (25 km is the EA approved distance to assume on this level of transportation). Typically these materials would be loaded into skips/containers so RO-RO vehicles best represent the transport which would be used.
Hartlebury	Non-Ferrous Recycling	Non-Ferrous Metal	25	743	RO-RO	
Hartlebury	Landfill	Reject Material	25	24,063	RO-RO	
Hartlebury EfW	IBA Recycling	IBA	52	15,759	Intermodal	This distance is that of the route between Hartlebury and the Castle Bromwich IBA recycling facility. This vehicle has been selected as it the best representation of the bulk transport of ash.
Hartlebury EfW	Landfill	APC Residue	64	3,683	Intermodal	This distance is that of the route between Hartlebury and the Bishop’s Cleeve Landfill. This vehicle has been selected as it is the closest match to the parameters of the tanker which would be used to remove the residue.

Additional transport distances and tonnages used in Option 7						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Hartlebury EfW	Ferrous Recycling	Ferrous metals	25	143	Intermodal	The distance was selected as it was assumed a ferrous reprocessor could be found within the county (EA default County level distance). This vehicle has been selected as it the best representation of the bulk transport of metals for recycling.

Additional transport distances and tonnages used in Option 8						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Madley Airfield	Runcorn EfW	RDF	185	30,413	Intermodal	This distance represents the distance between Madley and Runcorn. The RDF would be bulked for most efficient transfer hence the intermodal vehicles have been used.
Madley Airfield	Glass Recycling	Glass	25	2,497	RO-RO	This distance has been selected for all these options as it has been assumed that the necessary recycling and landfill facilities would be available within the county. (25 km is the EA approved distance to assume on this level of transportation). Typically these materials would be loaded into skips/containers so RO-RO vehicles best represent the transport which would be used.
Madley Airfield	Ferrous Recycling	Ferrous Metal	25	1,156	RO-RO	
Madley Airfield	Non-Ferrous Recycling	Non-Ferrous Metal	25	365	RO-RO	
Madley Airfield	Landfill	Reject Material	25	11,841	RO-RO	
Hartlebury	Glass Recycling	Glass	25	5,049	RO-RO	
Hartlebury	Ferrous Recycling	Ferrous Metal	25	2,335	RO-RO	

Additional transport distances and tonnages used in Option 8						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Hartlebury	Non-Ferrous Recycling	Non-Ferrous Metal	25	743	RO-RO	
Hartlebury	Landfill	Reject Material	25	24,063	RO-RO	
Hartlebury	Runcorn EfW	RDF	171	61,653	Intermodal	This distance represents the distance between Hartlebury and Runcorn. The RDF would be bulked for most efficient transfer hence the intermodal vehicles have been used.
Runcorn EfW	IBA Recycling	IBA	50	15,759	Intermodal	This distance has been assumed to represent the assumption that IBA recycling would be available within the region. (50 km is the EA approved standard for regional deliveries). This vehicle has been selected as it the best representation of the bulk transport of ash.
Runcorn EfW	Landfill	APC Residue	50	3,683	Intermodal	This distance has been assumed to represent the assumption that APC disposal would be available within the region. (50 km is the EA approved standard for regional deliveries). This vehicle has been selected as it is the closest match to the parameters of the tanker which would be used to remove the residue.
Runcorn EfW	Ferrous Recycling	Ferrous metals	25	143	Intermodal	The distance was selected as it was assumed a ferrous reprocessor could be found within the county (EA default County level distance). This vehicle has been selected as it the best representation of the bulk transport of metals for recycling.

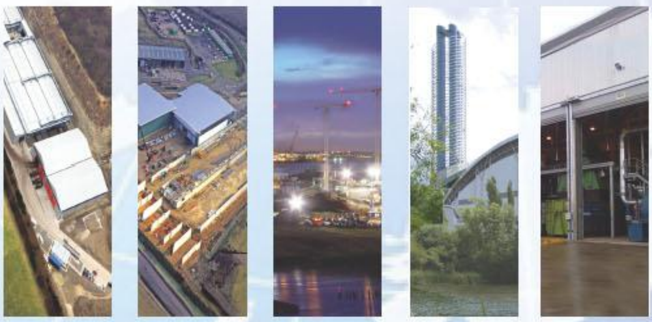
Transport distances and tonnages used in Option 9						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
C&I	Coventry	C&I Waste	25	29,080	Front End Loader	The distance was selected as it was assumed sufficient C&I could be sourced within the county (EA default County level distance). The vehicle was selected as it is typical for this type of collection and delivery.
Wyre Forest	Hartlebury Landfill	MSW	8	23,216	RCV	This is the distance between the assumed centre of arisings and the Hartlebury landfill. The vehicle was chosen as it is typical for kerbside collection.
Bromsgrove	Coventry	MSW	59	12,210	RCV	These are the distances between the assumed centre of arisings and the Coventry EfW. The vehicle was chosen as it is typical for kerbside collection.
Reddtch	Coventry	MSW	54	15,731	RCV	
Bromsgrove	HML Landfill	MSW	30	5,850	RCV	These distances are those between the centre of arisings in each WCA and the HML landfill. The vehicle selection is based on typical collection vehicles.
Wychavon North	HML Landfill	MSW	24	4,594	RCV	
Wychavon South	HML Landfill	MSW	8	5,065	RCV	
Malvern Hills	HML Landfill	MSW	27	8,911	RCV	
Worcester City	Allington EfW	MSW	287	17,916	RCV	This distance is that between the centre of arisings and the Allington EfW. The vehicle selection is based on typical collection vehicles.
Malvern Hills	Leominster WTS	MSW	40	4,647	RCV	This distance is that between the centre of arisings and the WTS. The vehicle selection is based on typical collection vehicles.
Wychavon South	Allington EfW	MSW	261	9,700	RCV	These distances are those between the centre of arisings in each WCA and the Allington EfW. The vehicle selection is based on typical collection vehicles.
Wychavon North	Allington EfW	MSW	272	7,560	RCV	
Leominster WTS	Allington EfW	MSW	330	29,870	Intermodal	These distances are those between the WTS facilities and

Transport distances and tonnages used in Option 9						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Rotherwas WTS	Allington EfW	MSW	293	10,989	Intermodal	the Allington EfW. The vehicle selection is the most representative of efficient bulk transport.
Coventry	Landfill	APC residue	50	2,246	Intermodal	This distance has been assumed to represent the assumption that APC disposal would be available within the region. (50 km is the EA approved standard for regional deliveries). This vehicle has been selected as it is the closest match to the parameters of the tanker which would be used to remove the residue.
Coventry	IBA Recycling	IBA	33	11,179	Intermodal	This distance has been assumed to represent the transport of IBA from the Coventry EfW to the Castle Bromwich bottom ash processor. This vehicle has been selected as it the best representation of the bulk transport of ash.
Coventry	Ferrous Recycling	Ferrous Metal	25	837	RO-RO	This distance has been selected as it is assumed that metals recycling will be available within the county. Typically the recyclable metals will be collected in skips/containers and transported to recycling facilities on RO-RO vehicles.
Allington EfW	Hazardous Landfill	APC Residue	50	3,106	Intermodal	This distance has been selected as it is assumed that hazardous landfill space will be available within the region. This vehicle selection best represents the tankers used to transport APC residue.
Allington EfW	Landfill	Rejects	25	5,904	Intermodal	This distance has been selected as it is assumed that landfill space will be available within the county. This vehicle selection represents the efficient bulk transport of rejects to landfill.

Transport distances and tonnages used in Option 9						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Allington EfW	Metals Recycling	Metals	25	884	RO-RO	This distance has been selected as it is assumed that metals recycling will be available within the county. Typically the recyclable metals will be collected in skips/containers and transported to recycling facilities on RO-RO vehicles.
Allington EfW	IBA Recycling	IBA	50	16,009	Intermodal	This distance has been selected as it is assumed that an IBA recycling facility is available within the region. This vehicle selection best represents the bulk vehicles used to transport IBA.
Wyre Forest	Hartlebury AD	Food waste	8	2,951	RCV	This is the distance between the assumed centre of arisings and the Hartlebury AD. The vehicle was chosen as it is typical for kerbside collection.
Bromsgrove	Hartlebury AD	Food waste	18	575	RCV	This is the distance between the assumed centre of arisings and the Hartlebury AD. The vehicle was chosen as it is typical for kerbside collection.
Wychavon North	Hartlebury AD	Food waste	10	860	RCV	This is the distance between the assumed centre of arisings and the Hartlebury AD. The vehicle was chosen as it is typical for kerbside collection.
Worcester City	Hartlebury AD	Food waste	18	2,282	RCV	This is the distance between the assumed centre of arisings and the Hartlebury AD. The vehicle was chosen as it is typical for kerbside collection.
Malvern Hills	Hartlebury AD	Food waste	35	173	RCV	This is the distance between the assumed centre of arisings and the Hartlebury AD. The vehicle was chosen as it is typical for kerbside collection.

Transport distances and tonnages used in Option 9						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Rotherwas WTS	Hartlebury AD	Food waste	64	3,206	Intermodal	This is the distance between the Rotherwas WTS and the Hartlebury AD. The vehicle selection is the most representative of efficient bulk transport.
Leominster WTS	Hartlebury AD	Food waste	52	1,572	Intermodal	This is the distance between the Leominster WTS and the Hartlebury AD. The vehicle selection is the most representative of efficient bulk transport.
Malvern Hills	Leominster WTS	Food waste	15	173	RCV	This is the distance between the assumed centre of arisings and the Leominster WTS. The vehicle was chosen as it is typical for kerbside collection.
Redditch WTS	Hartlebury AD	Food waste	29	3,729	Intermodal	This is the distance between the Redditch WTS and the Hartlebury AD. The vehicle selection is the most representative of efficient bulk transport.
Bromsgrove	Redditch WTS	Food waste	15	1,725	RCV	This is the distance between the assumed centre of arisings and the Redditch WTS. The vehicle was chosen as it is typical for kerbside collection.
Wychavon North	HML WTS	Food waste	24	699	RCV	This is the distance between the assumed centre of arisings and the HML WTS. The vehicle was chosen as it is typical for kerbside collection.
Wychavon South	HML WTS	Food waste	8	1,881	RCV	
Malvern Hills	HML WTS	Food waste	27	1,381	RCV	
HML WTS	Hartlebury AD	Food waste	32	3,961	Intermodal	This is the distance between the HML WTS and the Hartlebury AD. The vehicle selection is the most representative of efficient bulk transport.

Transport distances and tonnages used in Option 9						
Start	**Destination**	**Material**	**Distance (km)**	**Tonnage**	**Vehicle Type**	**Justification**
Hartlebury AD	AD recycling	Food waste	25	7,624	Intermodal	This distance has been assumed as it is expected that an end user for the AD output can be found within the county. The vehicle selection is the most representative of efficient bulk transport.



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Appendix C - Greenhouse Gas Assessment from EP Application

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SEVERN WASTE SERVICES

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GREENHOUSE GAS ASSESSMENT

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SEVERN WASTE SERVICES

ENVIRECOVER FACILITY

GREENHOUSE GAS ASSESSMENT

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TABLE OF CONTENTS

1 Greenhouse Gas Assessment

The assessment of the impact on national greenhouse gas emissions of the EnviRecover Facility is relatively complicated. This is because it is necessary to take account of the carbon emissions associated with the waste disposal which would have occurred if the waste were not to be combusted. The carbon in the waste is not entirely biogenic in origin, so only some of the carbon dioxide produced by the combustion plant needs to be taken into account. Finally, the power generated by the EfW plant would otherwise have been generated by other power stations, which would have released carbon dioxide.

1.1 Displaced Power

Most of the power generated in the UK is derived from nuclear, gas-fired and coal-fired power stations, with small amounts derived from renewable sources. It is important to consider which of these power sources would be displaced by the power generated by a new energy from waste plant. In the current electricity market, nuclear power stations operate as baseload stations, running essentially all the time, and renewable power stations operate as much as possible. This means that the power which would be displaced by a new plant would otherwise be generated by gas fired combined cycle gas turbine (CCGT) power plants and coal fired power plants.

The gas and coal fired generation comprises:

- 54% CCGT plants, which release around 373 kg CO_2/MWh
- 46% coal fired plants (835 kg/MWh).

While gas CCGT plants are more economic to operate than coal fired plants, in most cases, they are designed as base load plants, rapidly losing efficiency as their output is reduced. A review of the operating data of a number of coal and CCGT fired power stations in the UK in 2004 suggested that, for around 9 hours per day when the load is light, coal and gas fired stations are required to modulate their output to meet demand while, for 15 hours per day, it is mainly the more expensive coal fired power plants which modulate. However, with the recent changes in the relative prices of gas and coal, it is likely that coal-fired power stations are now operating as base load plants.

Given this uncertainty, in the base case we have assumed that a 50/50 mix of electricity generated from gas and coal would be displaced, but we have considered the sensitivity of the analysis to this assumption in Section 1.4.

Hence, the carbon dioxide emission associated with each MWh of displaced fossil power can be calculated as 604 kg/MWh (50% x 373 + 50% x 835).

1.2 Emissions from EfW Plant

The EnviRecover Facility will release carbon dioxide from the combustion of carbon. However, a proportion of the waste is derived from biodegradable materials. Carbon dioxide released from the combustion of biomass is not considered to contribute to global warming, since this carbon has been recently extracted from the atmosphere via photosynthesis. Therefore, it is only necessary to consider carbon dioxide released from the combustion of carbon derived from fossil fuels.

We have made the following assumptions:

- The plant processes 200,000 tonnes of municipal waste with a net calorific value of 8.2 MJ/kg. If the plant operates for 8,000 hours, then the hourly throughput will be 25 tonnes per hour;
- The waste contains 22.9% carbon by weight, based on a typical waste composition;

- 64% of the waste is biodegradable, as defined by the Government in the legislation for the Landfill Allowance Trading Scheme; and
- The EfW plant exports 13.3 MWe, giving a net electrical efficiency of 23.4%.

On this basis:

- The plant would export 532 kWh of power per tonne of waste;
- The carbon dioxide emissions would be 840 kg per tonne of waste, of which 302 kg is derived from fossil fuels;
- Nitric oxide would be released which would be equivalent to 23.6 kg of CO_2 per tonne of waste;
- A total of 65,176 tonnes of carbon dioxide equivalent would be released from non-biogenic waste burned at EnviRecover;
- 106,400 MWh of power would be exported, displacing a total of 64,266 tonnes of carbon dioxide; and
- Hence, there is a net increase in carbon dioxide emissions of 910 tonnes per annum.

1.3 Emissions from Landfill

Three processes take place in a landfill site which are relevant to this assessment:

- Biodegradation of the putrescible content (that part of the waste which is derived from biomass) occurs which produces a gas in which the principal components are carbon dioxide and methane. The gas produced is known as landfill gas. Because of the methane content, landfill gas released into the atmosphere is a potent cause of global warming;
- Capture of a proportion of the gas for use as a fuel in gas engine generation sets (known as landfill gas generation). This is a beneficial use because, like energy from waste it results in the displacement of fossil power; and
- Fixing of a proportion of the carbon content of the waste as non-reactive carbon which remains in the solid matrix. This process is known as sequestration and is beneficial with respect to that part of the sequestered carbon which is of fossil origin.

We have made the following assumptions:

- 69% of the carbon in the waste is sequestred, including all of the non-biodegradable carbon.[1]
- 55%[2] of the carbon is converted to methane and the remainder to carbon dioxide. Since the carbon dioxide is of biogenic origin, it does not count in the subsequent analysis.
- 78% of the methane at landfill sites is recovered and around 65% of the recovered methane is used to generate power[3]. However, it is noticeable that Eonomia, in their report "A Changing Climate for Energy from Waste?"[4], cite Dutch data giving lifetime capture rates of 10-55% and USA studies giving capture rates as low as 19%. The sensitivity of the results to this assumption has been assessed in Section 1.4.

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[1] This figure is higher than that assumed in the 17th Report of the Royal Commission on Environmental Pollution

[2] Landfill Gas Development Guidelines, ETSU 1996

[3] 2004 figures from the Environmental Services Association Annual Report 2005/06.

[4] Eunomia, "A Changing Climate for Energy from Waste, Final Report for Friends of the Earth", May 2006.

This means that:

- Methane equivalent to 48,103 tonnes of carbon dioxide would be released from the 200,000 tonnes of waste;
- 20,675 MWh of power would be generated, displacing power generation which would have generated 12,488 tonnes of carbon dioxide; and
- There is a net greenhouse gas production of 35,615 tonnes of carbon dioxide equivalent per annum.

1.4 Overall Comparison and Sensitivities

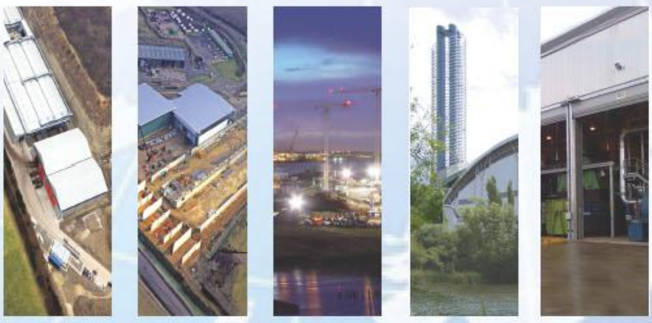
Overall, it can be seen that the EnviRecover Facility is predicted to reduce greenhouse gas emissions by around 38,780 tonnes of carbon dioxide equivalent per annum.

However, as discussed above, this conclusion is very sensitive to the assumed capture rate for landfill gas and the assumed power source which is displaced. The sensitivity of the conclusion to these variables has been considered and the results are shown in Table 1.1, where the figures in the table are the predicted reduction in greenhouse gas emissions in tonnes of carbon dioxide equivalent per annum.

Table 1.1 Greenhouse Gas Emissions – Sensitivity Analysis Results

Power Source Displaced	Landfill Gas Capture Rate			
	25%	40%	55%	78%
Coal	182,100	146,000	109,900	54,500
50% Coal & 50%Gas	159,100	123,900	88,700	34,700
Gas	136,000	101,700	67,500	14,900

It can be seen that a reduction in greenhouse gas emissions is predicted in every case, even if the displaced power source is gas and 78% of landfill gas is captured.



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Appendix D - Weinerberger Heat Use Report

MERCIA WASTE MANAGEMENT

ENVIRECOVER EFW FACILITY

CHP SCHEME TECHNICAL FEASIBILITY STUDY

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MERCIA WASTE MANAGEMENT

ENVIRECOVER EFW FACILITY

CHP SCHEME TECHNICAL FEASIBILITY STUDY

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Management Summary

Fichtner Consulting Engineers Ltd were engaged by Mercia Waste Management Ltd (MWM) to carry out a technical feasibility study into a potential heat export scheme to Wienerberger brickworks. The main aim of this study was to determine the viability of developing a CHP scheme for the EnviRecover facility.

The technical assessment demonstrated that exporting steam from the EnviRecover facility to preheat the Brick Work's secondary air from 95°C to 200°C, would result in a reduction in net electrical export of 0.15 MW for an air flow rate of 20,000 m^3/h and 0.39 MW for an air flow rate of 50,000 m^3/h.

The proposed solution utilises steam extracted from the turbine at approximately 22 bar(a) to supply a single tube bundle heat exchanger. This high pressure is required to achieve a sufficiently high saturation temperature to provide air at 200°C for the brickworks. The steam conditions from the boiler remain unchanged.

Since the scheme is not likely to be installed before 2013, based on current draft legislation it would be eligible for Renewable Heat Incentive (RHI) payments. Based on the draft legislation document an RHI tariff of £27/MWh_{th} has been applied in this study.

Based on the findings of this report, the 50,000 m^3/h air flow CHP scheme is viable from both a technical and commercial point of view with the predicted RHI payments. Similarly the 20,000 m^3/h option is also viable although margins would be dependant on the outturn capital costs of the project, primarily relating to the buried steam export pipeline.

Table of Contents

1 INTRODUCTION

1.1 Background

Mercia Waste Management Ltd (MWM) are proposing to meet the residual municipal waste management needs of Worcestershire County Council and Herefordshire County Council through the development of the Mercia EnviRecover facility, a purpose built energy from waste (EfW) plant, on land at Hartlebury Trading Estate. The planned opening date for the facility is 2014. It will have an installed electrical generating capacity of approximately 16 MW and will process approximately 200,000 tonnes per annum (tpa) of residual municipal waste through a single stream.

Fichtner Consulting Engineers Ltd were engaged by Mercia Waste Management Ltd (MWM) to carry out a feasibility study into a potential heat export scheme to Wienerberger brickworks. The main aim of the study was to determine the commercial and technical viability of developing the CHP scheme for the EnviRecover facility.

It is proposed that heat will be exported in the form of high pressure steam extracted from the turbine and the resulting condensate returned to the EnviRecover facility. The steam and condensate will be transported between Wienerberger brickworks and the EnviRecover facility in insulated pipelines buried in the roadway through the Harlebury Trading Estate. The proposed route for the pipeline is shown in Appendix A.

2 Conclusions

From the thermodynamic modelling process the following conclusions were reached.

(1) The proposed solution utilises steam extracted from the turbine at approximately 22 bar(a) to supply a single tube bundle heat exchanger which heats the brick works' secondary air from 95°C to 200°C. This high pressure is required to achieve a sufficiently high saturation temperature to provide air at 200°C for the brickworks.

(2) For an air flow rate of 20,000 m^3/h the heat export required (and therefore eligible for RHI payments) is 0.51 MW_{th}. For an air flow rate of 50,000 m^3/h the heat export required is 1.30 MW_{th}.

The equipment required to export heat to the Wieneberger brickworks was examined and the following conclusions were drawn.

(3) Based on the proposed pipeline route the length of the condensate and steam pipes would be circa 1030m. In this study, a separate return pipeline for flash steam is proposed, although the practicality of this pipeline would need to be reviewed as part of the final design.

In this study it was assumed that the three pipelines would be located in a single concrete service duct buried under the roadway. It was assumed that all three pipelines would be constructed from pre-insulated steel pipework rated to the applicable temperature and pressure. The steam pipeline to the brickworks would need an internal diameter of 2 inches for air flow rate of 20,000 m^3/h and 3 inches for air flowrate of 50,000 m^3/h.

Due to the pressures and temperatures involved the steam pipeline would require expansion bellows located throughout the pipeline, and for the purposes of this study this has been assumed to be every 100m. Inspection pits may also be required for each bellows unit to comply with the pressure equipment directive. Such pits were incorporated in the capital cost estimate. The condensate pipework from the brickworks would need an internal diameter of 1 inch or smaller in both scenarios.

(4) A heat exchanger would be required with a duty of 0.56 MW or 1.40 MW for air flow rates of 20,000 m^3/h or 50,000 m^3/h respectively. It is proposed that the heat exchanger would be a cross flow tube bundle design.

(5) Two condensate pumps operating in a 2 x 100% duty/standby arrangement would be required to return condensate to the deaerator in the EnviRecover plant from the heat exchanger on the brickworks.

(6) To provide the control loops required by the heat station, a dedicated control system would need to be installed. It would be necessary for this system to be fully integrated into the main plant control system and operated using the main SCADA screens.

Based on the findings of this report the commercial feasibility of the project was investigated and the following conclusion was made.

(7) Heat export to the brickworks with RHI support would be financially viable, particularly for the 50,000 m^3/h air flow case. The 20,000 m^3/h option is also viable although margins would be dependant on the outturn capital costs of the project, primarily relating to the buried steam export pipeline.

3 RECOMMENDATIONS

In order to progress the design of the CHP scheme further, the following points would need to be considered.

(1) The current plant design does not incorporate a turbine extraction at 22 bar(a). Depending on the likelihood of the CHP scheme going ahead the possibility of providing a turbine extraction at 22 bar(a) would need to be discussed with the potential contractors for the EfW construction and an indication obtained of any increase in turbine capital cost.

(2) The RHI scheme has not yet passed into legislation, although this is expected imminently. Based on the guidance notes and draft legislation wording, it appears that a CHP scheme such as the one proposed should be eligible for RHI payments. However this would need to be confirmed once the RHI scheme has officially passed into law.

(3) The internal diameter of the return pipework for condensate and steam would be very small. It would be useful to investigate whether this remaining heat could be used within the Wienerberger site. This would slightly reduce the capital costs and could potentially increase the quantity of heat eligible for RHI payments.

(4) The proposed solution does not include a sub-cooling zone within the heat exchanger and instead suggests a 5 bar(a) flash vessel to reduce the capital costs incurred from additional heat exchanger tube bundles. A more detailed analysis should be carried out to confirm the choice of this initial assessment.

(5) The detailed design for the pipe route and provisions for thermal expansion should be examined in more detail, to better understand the installation requirements.

4 Technical Feasibility

4.1 Design assumptions

As discussed in our proposal (S1200-0100-0481SAW) this initial study will be limited to a basic assessment of the viability of the scheme. A number of assumptions were required and these are stated below.

(1) Heat will be exported in the form of steam. This steam will be provided from an extraction from the turbine and will be exported via pre-insulated pipe to the nearby brickworks along the route shown in Appendix A.

(2) Wienerberger have an existing secondary air preheater, and MWM would not be required to provide a backup burner in the event the CHP system was off line.

(3) Based on a stated inlet temperature of 95°C the air density is taken to be 0.946 kg/m^3.

(4) The film heat transfer coefficient for the air side of the heat exchanger (λ_{air}) is estimated as 50 W/m^{2}K.

(5) The film heat transfer coefficient for the steam side of the heat exchanger (λ_{steam}) is estimated as 400 W/m^{2}K for the de-superheating section and 10,000 W/m^{2}K for the condensing zone.

(6) This study does not include the production of detailed control philosophies, PFDs, P&IDs, detailed assessment of the pipe routing or the detailed design of the piping scheme.

(7) The indicative capital costs of the equipment are based on our current database of projects; we have not approached the market to gain more accurate pricing.

4.2 Thermodynamic modelling

In order to assess the impact of heat export on the electrical output of the plant, the existing KPRO model of the EnviRecover facility (Case No 6 as described in S1277-010-0082MSS) was amended to include steam export. Three cases were created in this model as follows:

(1) Base Case: The heat export is zero. It is assumed that the turbine would be designed for the fully condensing case therefore a design case was required to size the turbine and allow the pressure drop with increasing extracted steam flow to be calculated.

(2) Case Load 2: The heat export is modelled for 20,000 m3/h air flow at the brickworks.

(3) Case Load 3: The heat export is modelled for 50,000 m3/h air flow at the brickworks.

A schematic representation of the thermodynamic model is shown in Appendix A.

4.2.1 Design basis

The parameters used in the thermodynamic model are listed in Table 1.

Table 1 - Assumed Operating Conditions		
Fuel Calorific Value	9.4	MJ/Kg
Steam pressure from the boiler	55	bar(a)
Superheater exit temperature	420	°C
Turbine isentropic efficiency	83%	
Steam export pressure	~23*	bar(a)
Steam export temperature	~310*	°C
Flash vessel operating pressure	5	bar(a)
Condensate return temperature	152	°C
* *value varies with steam export*		

4.2.2 Proposed solution

In order to provide the required heat to raise the temperature of the brickworks' secondary air from 95°C to 200°C, steam would be supplied from a dedicated turbine bleed.

The assumption was made that the turbine would be designed for the fully condensing case, i.e. no steam export, and the extraction would be uncontrolled. This means that as the quantity of extracted steam is increased the supply pressure will fall marginally. This was considered acceptable for such small steam flows. If much larger flows were envisaged at a later date, then a controlled extraction would need to be considered.

This pressure of this bleed was designed to be 23 bar(a) in the fully condensing case. For an air flow rate of 50,000 m^3/h the supply pressure was calculated to fall to 22.3 bar(a). Since a pressure of 21 bar(a) was required at the heat exchanger to provide air at 200°C, this was considered acceptable allowing for an estimated 1 bar pressure drop in the supply pipework.

This steam would be delivered via a 1,030m long pipeline and fed into a cross flow tube bundle heat exchanger. The heat exchanger would have a desuperheating section, where the steam donates its sensible heat, and a condensing zone, where the steam is condensed at constant pressure (~21 bar(a)).

The condensate is then piped to a flash vessel to reduce its pressure prior being returned to the EfW. This is done to reduce the risk of flash steam being produced in the return pipework. Condensate discharged from the heat exchanger will be at the saturation temperature (or slightly below). Therefore the pressure drop occurring in the 1,030m long return pipework would be likely to give rise to flash steam. To allow for this steam, the size of the return pipework would need to be increased, therefore increasing capital cost. By reducing the pressure in a controlled manner, the flash steam can be utilised. We have currently assumed that this steam is also returned to the EfW, although possibilities for using it at the brickworks should be investigated.

The resulting condensate would then be retuned to the EfW via condensate return pumps, increasing its pressure and therefore ensuring its temperature was well below saturation and therefore removing the possibility of flash steam being produced.

A schematic representation of the proposed solution is shown in Figure 1 below.

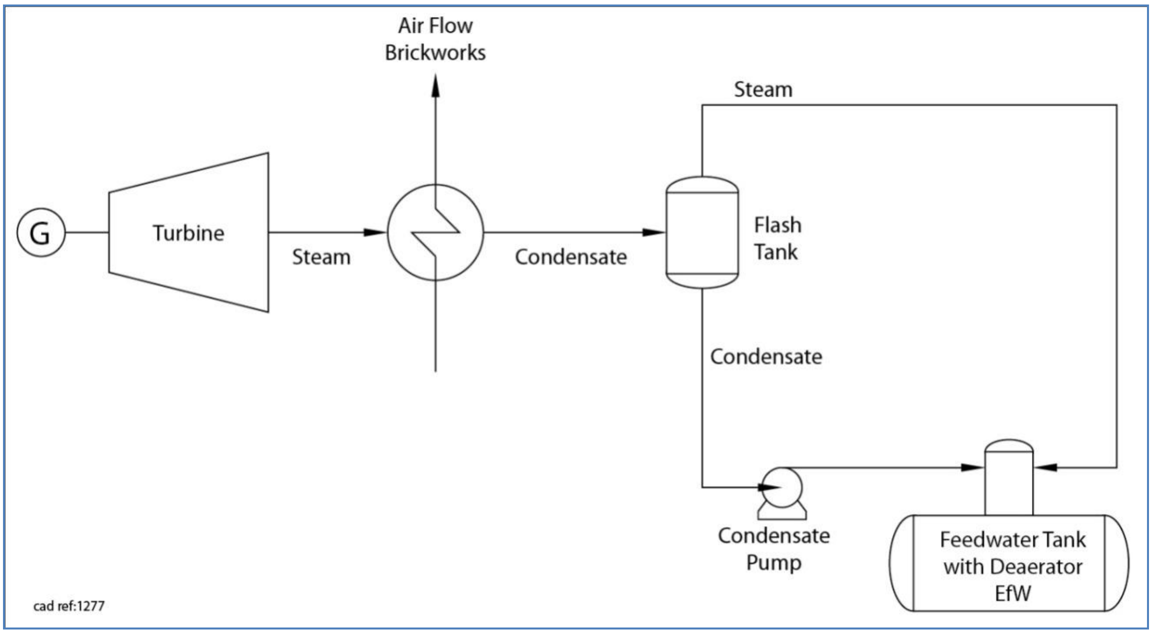


Figure 1 – Schematic diagram of proposed solution

Based on the air requirements we have calculated the duty of the heat exchanger. Table 2 below shows the main proposed solution parameters for the two scenarios.

Table 2 – Proposed solution parameters

	Units	Values
Secondary air 20,000 m^3/h		
CHP heat exchanger duty	MW	0.52
Steam export flow rate	kg/s	0.25
Steam pressure (heat exchanger inlet)	bar(a)	22.5
Steam temperature (heat exchanger inlet)	°C	312.4
Secondary air 50,000 m^3/h		
CHP heat exchanger duty	MW	1.3
Steam export flowrate	kg/s	0.61
Turbine bleed pressure (heat exchange inlet)	bar(a)	21.1
Turbine bleed temperature (heat exchange inlet)	°C	309.2

We have also investigated the possibility of sub-cooling the condensate instead of reducing the pressure in a flash vessel. If this option was chosen, the CHP heat exchanger dimensions would be significantly larger. Most of the heat transfer happens in the desuperheating and condensing zones, the driving force for heat transfer from the condensate to the air is much reduced and would therefore require a large surface area to increase the air temperature. It is also noted that increasing the differential temperature across the heat exchanger. For a given duty, sub-cooling the condensate would reduce the amount of steam required. Although this solution might sound appealing as the electrical export is higher, the steam flow rate is very low for both cases modelled and therefore this does not have a significant impact on the electrical efficiency of the plant.

4.3 Heat station equipment and layout

The major items of equipment that would be required are described in the following sections.

4.3.1 Steam and condensate pipework

The current design of the EnviRecover facility does not include steam export therefore additional pipework will have to be included in the tender package for steam and condensate to and from the CHP system.

We have sized the following connections:

- steam pipework between the turbine and the CHP heat exchanger;
- condensate pipework between the CHP heat exchanger and the flash vessel;
- flash steam return pipework between the flash vessel and the EfW feedwater tank/deaerator; and
- condensate pipework returning from the flash vessel to the EfW feedwater tank/deaerator.

We have used the software tool Fluid Flow v3.21.4 to determine the required diameters of these pipelines.

We have assumed a number of fittings and valves based on our experience and commonly used rules of thumb. The basis to determine the pipe diameter was to have a maximum velocity of 20 m/s on the steam line and 1.5 m/s on the condensate line.

The main parameters and results from the line sizing for the 20,000 m^3/h scenario are shown in **Error! Reference source not found.**.

Table 3 – 20,000 m^3/h case, Line sizing parameters and results

Type of fluid	From	To	Length [m]	Material	Size [in]	Fluid velocity [m/s]	Pressure drop [bar]
Steam	Turbine	Heat exchanger	1030	Carbon Steel	3″	6.01	0.4
Condensate	Heat exchanger	Flash Tank	10	Carbon Steel	1″	0.53	0.01
Steam	Flash Tank	Feedwater tank	1030	Carbon Steel	3/8″	0.31	1.2
Condensate	Flash Tank	Pump	5	Carbon Steel	1″	0.41	0.1
Condensate	Pump	Feedwater tank	1030	Carbon Steel	1″	0.41	0.8

The same approach has been taken for the 50,000 m3/h scenario. Parameters and the results are shown in Table 5.

Table 4 – 50,000 m3/h case, Line sizing parameters and results							
Type of fluid	**From**	**To**	**Length [m]**	**Material**	**Size [in]**	**Fluid velocity [m/s]**	**Pressure drop [bar]**
Steam	Turbine	Heat exchanger	1030	Carbon Steel	3 ½″	11.65	1.2
Condensate	Heat exchanger	Flash tank	10	Carbon Steel	1″	1.30	0.01
Steam	Flash tank	Feedwater tank	1030	Carbon Steel	½″	0.45	1.8
Condensate	Flash tank	Pump	5	Carbon Steel	1 ½″	0.44	0.1
Condensate	Pump	Feedwater tank	1030	Carbon Steel	1 ½″	0.44	0.5

The results in Table 3 and Table 4 show that even for the increased air flow rate case, the flow rate of condensate to be returned to the EfW is small which means that the return pipework could be of a very small diameter and still result in low fluid velocities. It is questionable whether returning such small amounts of condensate and flash steam to the EfW would be worthwhile compared with the capital cost of installing the pipework.

If return pipework was installed, although the maximum fluid velocity constraints could be met with pipe diameters as small as 1″ and 3/8″ for the 20,000m^3/h case, and 1 ½″ and ½″ for the 50,000m^3/h case, such small pipework would have reduced mechanical strength, requiring frequent pipe supports. It might therefore be preferable to use pipework of at least 2″ diameter for its improved rigidity. Alternatively it may be possible to incorporate return pipework connected, or incorporated within the steam supply pipework to provide increased mechanical strength. This could be investigated further during detailed design.

4.3.2 Heat exchanger

As discussed in section 4.2.2, the proposed solution would require one heat exchanger fed from a dedicated turbine extraction. Table 6 and Table 7 show the anticipated dimensions for the proposed heat exchanger, for the 20,000 m^3/h and 50,000 m^3/h scenarios respectively.

The heat exchanger would be an air-cooled steam condenser type and include a tube bundle, which generally has spiral-wound fins upon the tubes, and a motor driven variable speed drive fan, which moves the air across the tubes. The tubes would most likely be constructed from carbon steel, although aluminium could perhaps be an alternative. It is unlikely that stainless steel would be an economically viable option for the proposed duty due to the relatively low risk of corrosion.

It is most likely that the final tube row in the air path would be designed for de-superheating the steam to just above the saturation temperature. The saturated steam would then pass through the remaining tube rows arranged in parallel where it would condense. The first tube rows in the air path would see the coldest air and therefore the greatest temperature difference. The driving force for heat transfer in these tubes would be greater therefore more steam could be condensed. Hence although the tubes of the condensing section are arranged in parallel the mass flow through the tubes differs with the temperature difference.

Table 5 – Heat exchanger sizes, 20,000 m^3/h scenario

	Units	De-superheating zone	Condensing zone
Operating pressure	bar(a)	22.5	
Steam flow	kg/s	0.24	
Design duty	MW	0.06	0.46
Total design duty	MW	0.52	
Tube length	m	6	6
Bundle width	m	4	4
Number of tube rows	-	1	2
Area	m^2	48	97
Total design area	m^2	145	

Table 6 – Heat exchanger sizes, 50,000 m^3/h scenario

	Units	De-superheating zone	Condensing zone
Operating pressure	bar(a)	21.08	
Steam flow	kg/s	0.61	
Design duty	MW	0.15	1.15
Total design duty	MW	1.30	
Tube length	m	6	6
Bundle width	m	4	4
Number of tube rows	-	1	7
Area	m^2	49	339
Total design area	m^2	388	

It has been assumed that Wienerberger brickworks would require a constant demand of heated air from the heat exchanger. However if the heat demand was reduced (i.e. the brickworks was shut down for maintenance), the control system would reduce the duty on the heat exchanger by reducing the steam supply until the point at which the turbine was run in fully condensing mode. This arrangement would help to achieve the maximum possible plant electrical efficiency.

4.3.2.1 Modes of heat transfer and calculation of surface area

Due to the fact that the CHP heat exchanger is supplied with steam extracted from the turbine, this steam will be superheated when it enters the heat exchanger, as discussed in section 4.3.2. Predominantly two modes of heat transfer will take place, de-superheating and condensing. Since the heat exchanger would generally be sized with a design tolerance to ensure all the steam was condensed, some sub-cooling of the condensate is likely to take place. However in order to achieve significant sub-cooling a substantial increase in surface area would be required. However for the conditions modelled in this study the increase in heat transfer achieved by adding a sub-cooling section to the heat exchanger is unlikely to warrant the increase in capital cost that would result.

Steam enters the exchanger at the temperature and pressure outlined in Table 2 for the two scenarios (~95°C of superheat). It is then de-superheated to the steam saturation temperature (~216°C) and condensed at constant temperature.

The total heat duty for this case would be the following:

$$Q_{tot} = Q_{desuperheating} + Q_{condensing}$$

The surface area required would be calculated using the equation:

$$Q = U \cdot A \cdot \Delta T_{LM}$$

where

Q = heat duty (enthalpy change) [W]

U = heat transfer coefficient [W/(m^{2}K)]

A = heat transfer surface area [m^2]

ΔT_{LM} = log mean temperature difference [K]

The individual areas required for the de-superheating and condensing duties can be calculated using the equation above by replacing the values for Q, U and ΔT_{LM} with values appropriate to the local conditions where the heat transfer processes are taking place. De-superheating of the steam will occur in the region where the superheated steam enters the tube side of the heat exchanger. In this region, the value of Q is the lowest of the two processes, the value of ΔT_{LM} is the highest, and the value of U will likely be less than in the condensing section. Despite the lower heat transfer coefficient; the combination of a small duty (Q) and a large temperature difference (ΔT_{LM}) results in the de-superheating area being smaller than the area required for condensing.

In contrast to de-superheating, the area required for condensing is likely to be large as a result of the large duty (Q) for this process. In the condensing case, ΔT_{LM} is slightly lower than for de-superheating (since the steam is at saturation temperature). The overall heat transfer coefficient (U) will be slightly higher but is still largely controlled by the resistance of the air side heat transfer.

It is very difficult to accurately determine the heat transfer coefficient (U). Therefore we have used indicative values for the air and steam side and combined them using the overall heat transfer coefficient equation:

$$U = \frac{1}{\frac{1}{\lambda_{air}} + \frac{1}{\lambda_{steam}}}$$

where λ is the film heat transfer capacity and λ_{air} and λ_{steam} are as per assumptions (4) and (5) in section 4.1. We have excluded fouling resistances in this calculation as they are not likely to be significant in comparison with the relatively low value of λ_{air}.

A more rigorous method would employ computer software to determine local heat transfer coefficients in the heat exchanger geometry and consequently a more accurate estimate of the actual area required. However it is considered that the method used for the area calculation in this study is sufficient until such time as a more detailed design is required.

4.3.3 Flash vessel

Since the condensate discharge from the heat exchanger will vary with the heat load and the pressure of the condensate will be relatively high, we have included a flash tank between the heat exchanger and the condensate pumps. This tank would serve as a buffer tank and would operate at a pressure of approximately 5 bar(a).

We have sized the vessel and the approximate volume required would be lower than $1m^3$. This vessel would require a pressure gauge and a level indicator that would be connected to the control system. In addition, it is advisable to install a safety valve as this is a pressurised vessel, even thought the pressure is not very high.

4.3.4 Condensate pumps

As discussed in section 4.2.2, it is intended that the steam and condensate from the flash vessel would be returned to the deaerator/feedwater tank. In the existing model the deaerator operates at 3 bar(a) and the operating pressure of the flash vessel is 5 bar(a).

The condensate exiting the flash tank will be saturated and therefore at the 5 bar(a) saturation temperature (152°C). To ensure frictional pressure losses in the return pipeline do not give rise to further flash steam, the pressure of the condensate would need to be raised to take the saturation temperature well above that of the condensate. A condensate return pump would therefore be required. In addition, there would be insufficient pressure differential between the flash tank and deaerator during start up and low loads to return the condensate. To size the pump a discharge pressure of 10 bar(a) (saturation temperature of 180°C) has been assumed.

The design parameters of the condensate pumps are listed in Table 7. The intention is that two pumps would be installed with one duty and one standby.

On/off operation of the condensate pump would be linked to a level controller in the flash vessel which would switch on the pump once the minimum condensate level in the tank was exceeded.

Table 7 – Condensate pump data

	Units	Design figures [20,000 m3/h scenario]	Design figures [50,000 m3/h scenario]
Condensate pipe diameter	in	1”	1 ½”
Discharge pressure	bar(a)	10	10
Number of pumps	-	2 x 100%	2 x 100%
Volumetric flow rate per pump	m^3/h	65	65

It has been assumed that a constant base heating load will be exported to brickworks therefore the condensate pump would be expected to operate at a constant flow rate and suction head pressure. However to allow for potential low load conditions it may be beneficial to install variable speed drives liked to the flash tank level controller. A minimum flow line back to the flash tank may also be advisable to allow for particularly small flows. An alternative arrangement could be to have a fixed speed pump and a three way valve linked to the buffer tank level controller which would vary the flow between re-circulation and discharge to the feedwater tank. The optimum arrangement could be examined further during detailed design.

Since the condensate from the CHP heat exchanger is saturated, the risk of suction side cavitation could be significant. To ensure there is sufficient positive net suction head during all operational conditions it would be good practice to mount the flash tank at least 0.5 - 1m above the condensate pumps. To ensure the heat exchanger could be drained by gravity it would also need to be installed higher than the flash tank.

4.3.5 Heat station control system

As discussed in section 4.3.2, it has been assumed that Wienerberger brickworks can accept a constant base heating load equal to the heat required to preheat the secondary air for the Kiln. Therefore the duty on the heat exchanger would remain constant. However in reality it is likely that the heat export from EnviRecover would need to vary and this would require some level of control.

The following parameters of the heat station would require control:

- steam flow to the heat exchanger;
- condensate flow to the deaerator/feedwater tank; and
- condensate level within the flash vessel.

The control loop for steam flow to the heat exchanger would consist of a temperature probe at the air side discharge of the heat exchanger and a control valve on the steam supply to heat exchanger. If the secondary air flow rate from the brickworks was reduced, the outlet air temperature from the heat exchanger would start to increase. The temperature controller at the outlet of the heat exchanger would be set at 200°C and would therefore start to close the control valve to throttle back the steam flow and reduce the condensing pressure, maintaining the outlet temperature at 200°C.

The condensate return control loop is discussed in section 4.3.4. The variable speed drive of the condensate pump would be linked to the level controller for the flash tank. However an isolation valve would also be required at the inlet to the feedwater tank linked to a high level trip for the feedwater tank. In the event of this valve closing, the back pressure at the condensate pump would rise sharply and the pump would either need to shut down or re-circulate flow to the flash tank. This arrangement should be examined in more detail during the detailed design phase.

In order to provide the control loops discussed above, a dedicated heat station control system could be installed, although it would be necessary for it to be fully integrated into the main plant control system and operated using the main SCADA screens. Alternatively it might be possible to expand the proposed DCS to incorporate the heat station control loops.

5 Government CHP Incentive Schemes

At the time the EnviRecover EfW Facility is due to be commissioned, the Renewable Heat Incentive (RHI) and Levy Exemption Certificates (LECs) schemes should be in place. Currently, any new CHP scheme commissioned after April 2013 will no longer be able to apply for Renewable Obligation Certificates (ROCs) and can only be eligible for the RHI, therefore ROCs have not be considered as part of this study.

5.1 Biogenic content

The amount of LECs and RHI payable are both proportional to the biogenic content of the waste burned. The RHI requires that municipal waste must have a minimum bioenergy content of 50%. This differs from other incentive programmes such as the Renewables Obligation Order (ROO) where the level of support is dependent on the bioenergy content of the fuel but no minimum is specified.

With regard to proving the bioenergy content of the waste, this is covered in the Renewable Heat Incentive Guidance – Volume 2: Ongoing obligations, payments. This document states the following with regard to proving the fossil fuel proportion of municipal waste:

"In certain circumstances, we are allowed under the Regulations to make an assumption about the biomass portion of a municipal waste stream upon receipt of satisfactory information published by certain bodies. This is where information demonstrates that the fossil derived portion of the waste is unlikely to exceed 50 per cent (and that therefore the solid biomass proportion of municipal waste is at least 50 per cent). Upon receipt of this information we are able to assume that the fossil fuel portion of a municipal waste stream is 50 per cent.

In practice, this allows installations to base their Fuel Measurement and Sampling (FMS) approach on the submission of published data, rather than requiring regular sampling by the participant. In this case participants will need to gather the evidence they wish to draw upon in order to clearly demonstrate the fossil fuel derived energy content of the fuel.

Where a participant wishes to claim credit for the renewable content of their municipal waste being greater than the 50 per cent assumed under the previous approach, they will need to propose FMS procedures that will demonstrate this."

The information provided must take account of any waste processing and separation that takes place between collection and combustion. Ofgem have the right to request sampling to verify the information provided, as indicated below. This is covered in more detail in the Renewable Heat Incentive Guidance – Volume 2.

"In order to verify the proportion of solid biomass contained in municipal waste, the Regulations allow us to request that a participant either provides a sample of municipal waste used in an accredited installation or implements a sampling regime. The Regulations also give Ofgem the discretion to take account of sampling conducted on any gas or other substance produced as a result of the fuel being used. We may also request a sampling regime as part of our auditing procedures."

There are also initial plans to introduce carbon 14 sampling of flue gas to determine the biogenic content with one pilot scheme currently being operated.

5.2 Renewable Heat Incentives (RHI)

The Renewable Heat Incentive (RHI) draft regulation was initially put forward by DECC for review in March 2011, along with a policy document. In June 2011, the amended regulation (Renewable Incentive Regulation 2011) was published, along with two Guidance Documents from Ofgem. The regulation is currently awaiting full parliamentary and StateAid approval.

The RHI proposes to allow facilities exporting heat to gain additional income based on the amount of heat exported. The guidance states that:

"In general, only the installation of new equipment will be eligible for the incentive." "Any increase in capacity would be eligible for RHI support as if it were a new installation. New installations would also be eligible where they replace existing installations, but refurbishment, repair or conversion of equipment would not create any RHI entitlement beyond that which was in place before such works were carried out."

EnviRecovery EfW would be a new facility, and would therefore be eligible for RHI support.

The regulation states a price of £27 per MWh of heat exported for facilities exporting 1 MW_{th} and above. Payment is purely on the basis of the quantity of heat exported. The regulation expresses the view that by making RHI payments on the basis of heat output, this will provide sufficient incentive for a facility to generate heat and power as efficiently as possible. There will therefore be no "Quality Index" figure as per the Renewable Obligation Order (ROO).

The regulation indicates that RHI income will be available for 20 years of operation.

5.3 Levy Exemption Certificates (LECs)

The Climate Change Levy (CCL) is one of a range of measures designed to help the UK meet its commitment to reduce greenhouse gas emissions. The Levy is chargeable on the industrial and commercial supply of taxable commodities such as electricity, gas, diesel etc. Facilities generating power from renewable sources are eligible to claim Levy Exemption Certificates (LECs) on the net power exported.

Currently there are two types of LEC available: Renewable Energy LECs; and Combined Heat and Power (CHP) LECs.

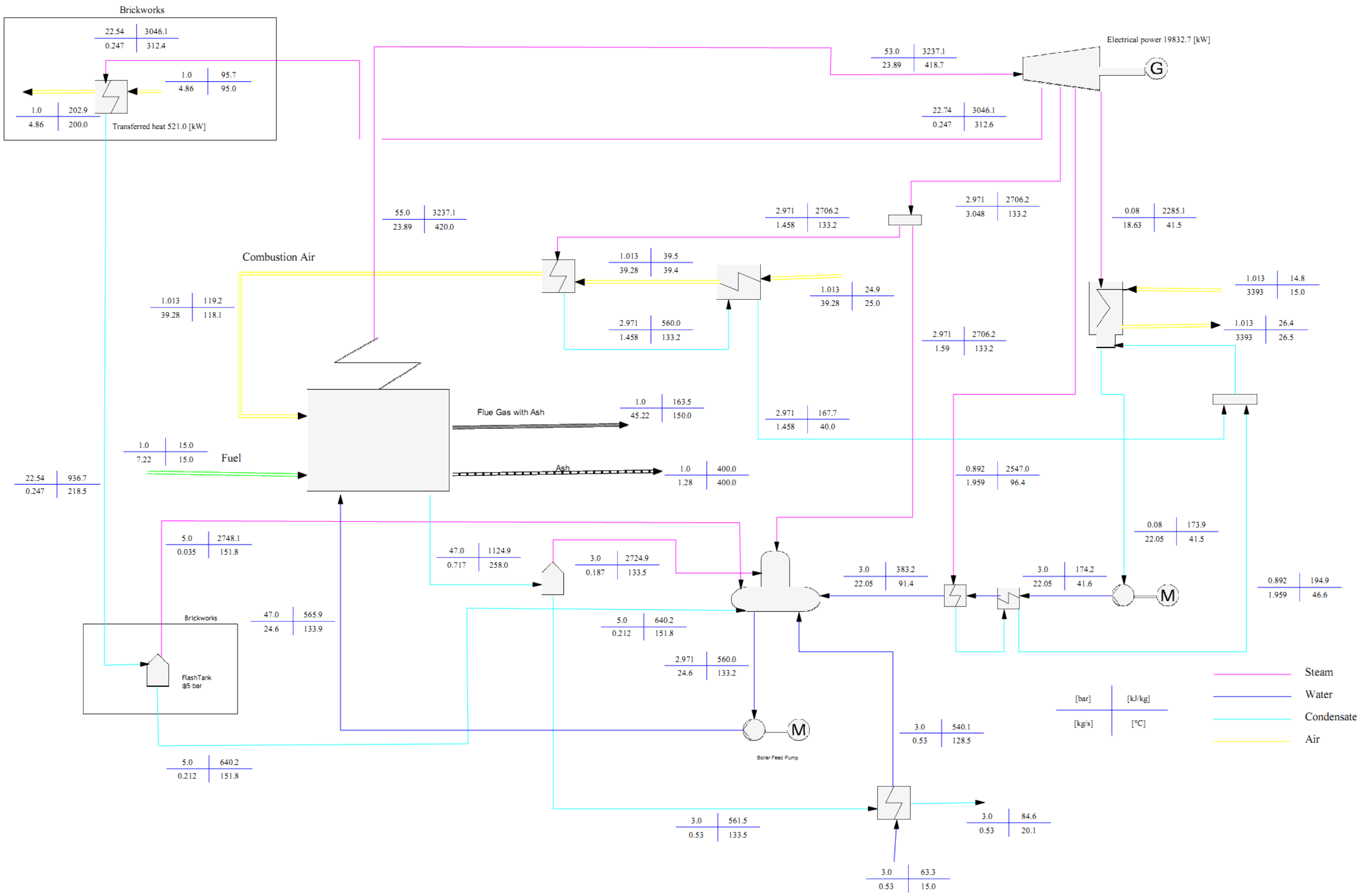
Renewable Energy LECs are available to facilities generating renewable power. Such facilities are eligible to claim a maximum of 1 LEC per MWh exported. The proportion of the power qualifying is dependent on the renewable energy content of the fuel, which for EnviRecover is 50% hence 0.5 LECs/MWh. Since this benefit could be claimed by the existing plant, the reduction in electrical export due to the export of steam to Wienerberger would also reduce the number of LECs which could be claimed. This therefore needs to be considered as a cost when assessing the viability of the scheme.

The second form of LECs currently available are CHP LECs. However, because of the introduction of the carbon price floor (CPF) as part of the electricity market reform (EMR), CHP LECs can no longer be claimed after 1st April 2013. The CPF removes the exemption for electricity producers under the Climate Change Levy (CCL) and replaces it with the carbon price support (CPS) rate. As part of removing the exemptions, the additional exemptions for CHP (including CHP LECs) are removed.

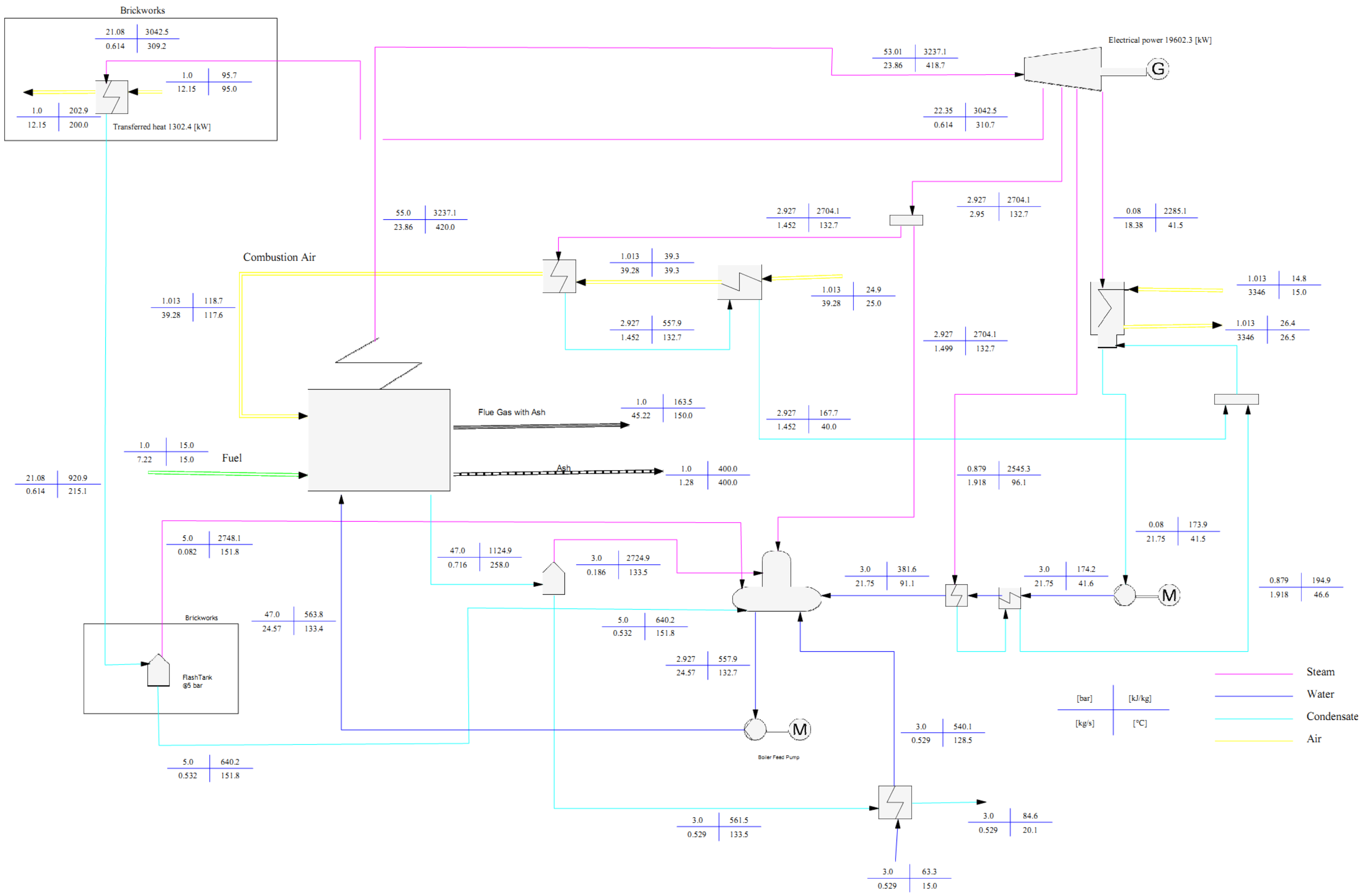
The market value of a LEC from the 1st April 2011 is £4.85. This figure has been historically indexed at RPIx by the government.

Appendix A – Proposed steam/condensate pipe route for CHP to Wienerberger

Appendix B - Thermodynamic modelling heat balance 20,000m³/h case



Appendix C - Thermodynamic modelling heat balance 50,000m^3/h case



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Appendix E - Response to Peter Luff MP

E.1 Peter Luff MP has written a letter to the Planning Inspectorate regarding the Inquiry. I would like to respond to two points made in this letter.

E.2 Firstly, Mr Luff states *that "[The Application] would also reduce the flexibility to bring forward any emerging technology for waste disposal for at least 25 years. Plasma arc disposal is a leading example of the type of emerging technology likely to be superior to conventional incineration of the kind proposed for this* scheme.".

E.3 Plasma gasification uses a high temperature electric arc furnace to break down the components of the waste feedstock into a residue which is presented as a vitrified solid and low molecular weight gases. This produces a fuel gas which then has to be cleaned of sulphur and chlorine gases but which contains very little condensable tars. It is these condensable tars which have proved difficult to deal with in attempts to produce a synthetic gas from waste suitable for use in a gas turbine or gas engine.

E.4 Plasma gasification is not yet available at commercial scale in a complete form. While there are two operational plants in Japan (albeit some five times smaller than the proposed Envirecover Facility), both plants merely combust the syngas. One of these plants generates no electricity and the other exports very little due to the high electrical consumption.

E.5 A more elegant plasma gasification process is that being developed by Advanced Plasma Power (APP), who have a pilot plant in operation and are currently developing a demonstration plant. This uses a fluidised bed gasifier to generate the fuel gas and then a plasma arc furnace to break down the gases into low molecular weight components. The electricity required within the process is therefore significantly less than that required by a straight plasma arc process. However, the APP process has a limited capacity and is yet to be proven in commercial operation.

E.6 Secondly, Mr Luff makes a number of assertions on climate change and energy efficiency. I provide evidence which disagrees with these statements in my main proof.

Appendix F

Extracts from Consultation on 2011 Renewables Obligation Order

Government Response to the Statutory Consultation on the Renewables Obligation Order 2011

December 2010

Chapter 2: Sustainability Criteria for Biomass and Biogas

Summary

- Solid biomass and biogas electricity will need to have a carbon intensity of 285.12 $kgCO_2$/MWh or lower to be eligible for ROCs from April 2013;
- The direct land use criteria will be consistent with the Renewable Energy Directive (RED). We also intend to consider how any proposals to address indirect land use change (ILUC), currently being considered by the European Commission for biofuels, could apply to biomass and biogas;
- Sustainability reporting will also be required on the mass/volume, type of biomass, its format, whether energy crop or production residue, whether an environmental certification has been met, and if so which one, and country of origin;
- Mandatory reporting against the sustainability criteria will be introduced from April 2011 for all generators above 50kW, based on a standard GHG calculating tool to be launched next year;
- From April 2013, generators of 1MW and above will need to meet the sustainability criteria in order to be eligible for support;
- Waste, biomass wholly derived from waste, landfill gas or sewage gas will not need to meet the sustainability criteria and will not need to report on sustainability;
- An expanded Working Group will support the introduction of the criteria, and the development of a sustainable forest management approach.

Introduction

36. The ROO 2011 Consultation set out our proposal to introduce mandatory sustainability criteria for solid biomass and biogas. We sought views on the following:

- A minimum 60% Greenhouse Gas (“GHG”) emission saving for electricity generation using solid biomass or biogas relative to the EU fossil fuel comparator (a carbon intensity target of 285.12 $kgCO_2$/MWh or lower).
- Land use criteria in line with the EU Renewable Directive approach to biofuels and bioliquids.

Appendix G

Extracts from Preliminary Consultation on Renewables Obligation

NEW & RENEWABLE ENERGY

Prospects for the 21st Century

The Renewables Obligation Preliminary Consultation

dti
Department of Trade and Industry

The basis on which licensed suppliers choose to comply with the Obligation, and obtain evidence that they have done so, is a matter for them and the generators or intermediaries with whom or through whom they have chosen to contract.

The acceptability of any ROC as evidence that a licensed supplier has supplied eligible renewable electricity to a customer in Great Britain will be a matter for OFGEM. The use of such a ROC for any purpose other than as evidence of compliance with the Renewables Obligation, for example international trading or domestic retail sales, is a matter for those engaging in such activity, although OFGEM will have to be notified of all such sales that occur.

2.3 Suppliers Affected by the Obligation

As outlined in *Conclusions in Response to the Public Consultation*, the Government has been actively considering whether it would be worthwhile to exempt certain categories of licensed electricity suppliers from the Obligation, specifically those with a very low percentage market share, recent entrants into the marketplace and those already involved in the voluntary green market.

However, **the Government proposes that the Obligation should apply to all licensed electricity suppliers in England and Wales.** It believes that this inclusive approach is necessary from day one if targets are to be met, and if individual supply companies are to recognise that the Government is serious in its commitment to the Obligation.

While Government recognises that smaller companies may face some initial difficulties (for example, with costs and access to renewables), companies in this situation will be able to choose the buy out option to comply with the Obligation. Given that compliance will be judged against a supplier's total supplies in the year being assessed, new entrants may also be more likely to choose the buy out option.

2.4 Eligible Renewables

All sources of renewable energy are at different stages of development in Great Britain. Large scale hydro, (i.e. exceeding 10MW installed capacity) and energy from waste (energy recovery from municipal solid waste [MSW] and from mixed streams of industrial and commercial waste [ICW]) are already commercially viable, well established in the market, and can compete with electricity from fossil fuels. **For this reason, the Government considers that these two renewable energy sources, large scale hydro and energy from waste, should be excluded from the Obligation.** This will allow resources to be targeted more effectively on those renewables needing continued support.

The proposed European Directive on the promotion of electricity from renewable energy sources in the internal electricity market (Com (2000) 279 final) contains a definition of those renewable sources of

Table B: Summary of Incentives for Renewables

Source	10% Target	Renewables Obligation[11]	CCL Exemption[12]	Capital Grants
Landfill Gas	✓	✓	✓	
Sewage Gas	✓	✓	✓	
Energy from Waste[13]	✓		✓	
Hydro exceeding 10 MW installed capacity	✓			
Hydro 10 MW or less, installed capacity	✓	✓	✓	
Onshore wind	✓	✓	✓	
Offshore wind	✓	✓	✓	✓
Agricultural and forestry residues	✓	✓	✓	
Energy crops	✓	✓	✓	✓
Wave Power	✓	✓	✓	
Photovoltaics	✓	✓	✓	

energy that Member States will be able to count towards their national targets. The question of whether energy from waste should be included in national targets for renewables is still under discussion in Europe.

Renewables such as small scale hydro, onshore wind and agricultural and forestry residues are unlikely to develop further without the stimulus provided by the Obligation. Bringing development of offshore wind and energy crops forward will be particularly important if the 10% target is to be met. The Government believes that this can best be achieved by additional support through a system of capital grants for early commercial projects. Renewables such as wave and photovoltaics will need further development before they are likely to be able to play a more significant role in the renewable energy portfolio.

Electricity generated by projects contracted under NFFO-3, 4 and 5 will be eligible for the RO and exempt from the Climate Change Levy to

Table C: Regional Variations

	Renewables Target	Renewables Obligation	CCL Exemption[14]
England/Wales	✓	✓	✓
Scotland	✓	✓ (RSO)	✓
Northern Ireland	✓		✓

[11] The Government has no plans to disqualify any of the renewables proposed to be eligible during the life of the Obligation

[12] Subject to Parliamentary Approval

[13] Energy recovery from municipal solid waste (MSW) and from mixed streams of industrial and commercial waste (ICW)

[14] The Climate Change Levy applies throughout the whole of the United Kingdom.

Appendix H

Extracts from Renewable Energy Directive

HAVE ADOPTED THIS DIRECTIVE:

Article 1

Subject matter and scope

This Directive establishes a common framework for the promotion of energy from renewable sources. It sets mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy and for the share of energy from renewable sources in transport. It lays down rules relating to statistical transfers between Member States, joint projects between Member States and with third countries, guarantees of origin, administrative procedures, information and training, and access to the electricity grid for energy from renewable sources. It establishes sustainability criteria for biofuels and bioliquids.

Article 2

Definitions

For the purposes of this Directive, the definitions in Directive 2003/54/EC apply.

The following definitions also apply:

(a) 'energy from renewable sources' means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases;

(b) 'aerothermal energy' means energy stored in the form of heat in the ambient air;

(c) 'geothermal energy' means energy stored in the form of heat beneath the surface of solid earth;

(d) 'hydrothermal energy' means energy stored in the form of heat in surface water;

(e) 'biomass' means the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste;

(f) 'gross final consumption of energy' means the energy commodities delivered for energy purposes to industry, transport, households, services including public services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission;

(g) 'district heating' or 'district cooling' means the distribution of thermal energy in the form of steam, hot water or chilled liquids, from a central source of production through a network to multiple buildings or sites, for the use of space or process heating or cooling;

(h) 'bioliquids' means liquid fuel for energy purposes other than for transport, including electricity and heating and cooling, produced from biomass;

(i) 'biofuels' means liquid or gaseous fuel for transport produced from biomass;

(j) 'guarantee of origin' means an electronic document which has the sole function of providing proof to a final customer that a given share or quantity of energy was produced from renewable sources as required by Article 3(6) of Directive 2003/54/EC;

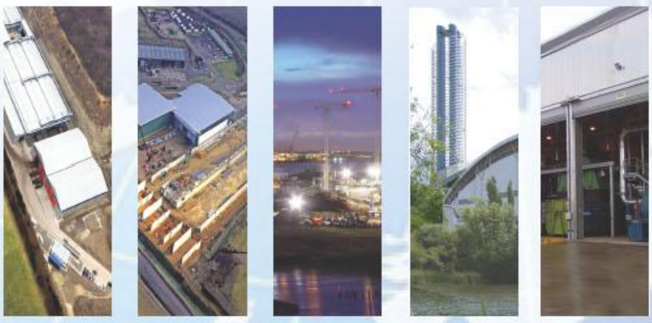
(k) 'support scheme' means any instrument, scheme or mechanism applied by a Member State or a group of Member States, that promotes the use of energy from renewable sources by reducing the cost of that energy, increasing the price at which it can be sold, or increasing, by means of a renewable energy obligation or otherwise, the volume of such energy purchased. This includes, but is not restricted to, investment aid, tax exemptions or reductions, tax refunds, renewable energy obligation support schemes including those using green certificates, and direct price support schemes including feed-in tariffs and premium payments;

(l) 'renewable energy obligation' means a national support scheme requiring energy producers to include a given proportion of energy from renewable sources in their production, requiring energy suppliers to include a given proportion of energy from renewable sources in their supply, or requiring energy consumers to include a given proportion of energy from renewable sources in their consumption. This includes schemes under which such requirements may be fulfilled by using green certificates;

(m) 'actual value' means the greenhouse gas emission saving for some or all of the steps of a specific biofuel production process calculated in accordance with the methodology laid down in part C of Annex V;

(n) 'typical value' means an estimate of the representative greenhouse gas emission saving for a particular biofuel production pathway;

(o) 'default value' means a value derived from a typical value by the application of pre-determined factors and that may, in circumstances specified in this Directive, be used in place of an actual value.



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