Environmental impact assessment of alternate weekly residual waste collection with weekly food waste collection using WRATE

DRAFT REPORT for:

Brighton & Hove City Council

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ORGANIC RESOURCE AGENCY LTD

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1 Executive summary

A life cycle assessment was carried out by the Organic Resource Agency on behalf of Brighton and Hove City Council to assess the environmental impact of reducing residual waste collections to alternate weeks and introduction of a weekly food waste collection to the ‘suburban’ residents of Brighton and Hove. Two future scenarios were modelled including food waste collections – one utilising anaerobic digestion and one in-vessel composting. It was found that although small environmental gains could be made through both treatment options, the advantages were not large in both cases, as the Council have invested in modern energy from waste technology and little material is landfilled. Transport use was found to be the largest environmental burden under all collection scenarios.

2 Introduction

The Organic Resource Agency Ltd (ORA) was asked by Brighton & Hove City Council (the Council) to undertake an independent life cycle assessment (LCA) which would quantify the impact on the environment from the introduction of a weekly food waste collection service and fortnightly residual waste collection to the city's suburban population.

3 WRATE

3.1 Using WRATE

ORA's favoured method of conducting an LCA for municipally collected waste is to use WRATE (the Waste and Resources Assessment Tool for the Environment). WRATE is a software package administered by the Environment Agency for conducting LCA analyses for waste management scenarios. It has been specifically developed for modelling the flows of municipal waste and the various treatments which are currently found in the UK.

3.2 Limitations of the software

The accuracy of the results from WRATE are dependent on a number of factors, but most importantly, the data on which it is based and the method of calculation within the model. The data on which the model is based has been obtained from a variety of organisations and literature. This data has been peer reviewed, and although disagreements may always occur, ORA feels that the review process puts WRATE in a strong position to produce useful results.

WRATE cannot handle every imaginable waste management scenario, and so compromises have to be made in order to model reality. For example, the model does not contain data to model semi-dry scrubbing systems in incinerators (such as that employed at Newhaven), and so the closest matching process must be modelled instead (dry scrubbing in the Newhaven case). Another limitation of the software is that battery recycling is not accounted for, and so the final results do not include the impact from this.

WRATE is also limited, along with all methods of LCA, regarding the underlying science on which it is based. For example as climate science has advanced, our knowledge of the relative impact from different greenhouse gases on global warming has increased. This has led to changes in the weighting applied to different gases in the GWP (global warming potential) assessment. WRATE is based on up-to-date weighting in this respect although this is likely to change in the future as our understanding advances.

The version of the software used by ORA was WRATE v.2.0.1.4.

3.3 Objectives

The objective of this work is to provide the Council with an independent LCA which models and shows the difference between likely future waste management scenarios in terms of their impact on the environment.

3.4 Scope

Due to the practicalities of implementing a food waste collection scheme across the whole of Brighton and Hove, ORA was asked to carry out the LCA on the city's suburban population which numbers around 80,000 households, excluding houses of multiple occupancy (HMOs) and flats.

4 Methodology

4.1 Calculation of composition and tonnage

The composition of residual waste and recycling found in the 2007 waste audits performed on behalf of the Council was re-proportioned according to the ACORN[1] categories shown in Table 1 which represent 'suburban' Brighton and Hove. This new composition, combined with current tonnage information from the Council forms the basis for the baseline scenario (see Section 4.2).

The baseline tonnage and composition were then passed through the "tonnage impact model" which was previously developed by ORA to predict the change that introduction of alternate weekly residual waste collections and collection of food waste would have. This then provided a future waste composition (for residual waste, recycling and food) which could be used in the AWC scenarios (see Section 4.2). The compositions of waste used in the model are shown in Appendix A and the translation of categories from the Council audit to WRATE in Appendix B.

4.2 Scenarios

Three scenarios were modelled in the LCA. In all of these 95% of the residual waste is treated through incineration at Newhaven and 5% is landfilled at Lidsey, West Sussex. Scenario maps showing the flow of material through the process are shown in Appendix D. The three scenarios are:

1. **Baseline**. This scenario models a situation where there is no separate food waste collection and residual waste is collected weekly. Recyclates are collected on alternate weeks.

2. **AWC with AD**. This scenario models a weekly food waste collection and alternate weekly collection of residual waste and dry recyclables. The food waste is sent to a hypothetical anaerobic digestion facility at Whitesmith, East Sussex. Dense plastic and aluminium foil recycling are offered as additional recyclables.

3. **AWC with IVC**. This scenario models a weekly food waste collection and alternate weekly collection of residual waste and dry recyclables. The food waste is sent to the existing in-vessel composting (IVC) facility at Whitesmith. Dense plastic and aluminium foil recycling are offered as additional recyclables.

[1] ACORN = A Classification Of Residential Neighbourhoods

5 Assumptions

The waste composition used in the LCA is based on a series of audits carried out on behalf of the Council in 2007 for both residual waste and recycling. These audits separately accounted for time of year (split into four phases) and different socio-economic groups (split by ACORN category. This provided ORA with a large body of information from which to work. The tonnage of waste and recycling currently generated by residents was provided by the Council, split into different collection rounds.

For the purposes of the LCA three collection rounds were used on which to base the model. These were West Hove (food waste trial area), Saltdean and Lower Hollingbury as it was felt that combined, these three areas would represent 'suburban' Brighton and Hove. The ACORN breakdown of these areas was provided by the Council and is shown in Table 1.

	West Hove	Saltdean	Lower Hollingbury	Total
ACORN 1	825	3,068	785	4,678
ACORN 2	1,840	11	1,322	3,173
ACORN 3	2,152	1,964	2,870	6,986
ACORN 4	1,201	316	342	1,859
ACORN 5	196	0	327	523

Table 1: Number of households split by ACORN category in sample areas. ACORN 1 represents "wealthy achievers", ACORN 2 represents "urban prosperity", ACORN 3 represents "comfortably off", ACORN 4 represents "moderate means" and ACORN 5 represents "hard pressed".

The two future scenarios which include the implementation of a food waste collection scheme have a number of assumptions in terms of the overall amount of waste which is diverted. It is assumed that for food waste a 62% capture rate and a 66% participation rate are realistic. These figures were provided by the Council's own modelling exercise and give an overall rate of 41% recycling for this stream. The additional dry recyclable materials which residents will also be able to recycle, namely dense plastic and aluminium foil, are assumed to have the same capture and participation rates as existing dry recyclables before implementation of the new scheme.

Contamination in the food waste stream is not accounted for in the WRATE model. Although contamination would have an operational effect on processing facilities it should not have a major effect on the environmental burdens assessed as part of the LCA.

The electricity mix which is used in WRATE for offsetting environmental burdens is that for “UK 2011”. Therefore this modelling exercise would give a different result if it was repeated in the future. An increasing amount of renewables in future electricity mixes will reduce environmental savings which are made currently via incineration and anaerobic digestion.

6 Results

The results from the WRATE LCA are shown graphically in Figures 1 to 6 and tabulated in Appendix C. These are the six high level environmental burdens:

- global warming potential (GWP)
- acidification (acid rain)
- eutrophication
- freshwater aquatic ecotoxicity
- human toxicity
- resource depletion

Graphs showing the impact from the three scenarios (Figures 1 to 6) include a breakdown of each scenario to show which components of the waste management system have the most effect. The components are:

- Collection (this represents waste receptacles only)
- Transportation
- Intermediate facilities (includes transfer station and MRF)
- Recycling (impact from recycling materials)
- Treatment and recovery (includes EfW, AD and IVC)
- Landfill

For example the global warming potential results (Figure 1) show that in all scenarios, recycling has the largest effect, followed by treatment and recovery.

Whilst positive results (above the bold lines) represent detrimental environmental impacts such as emissions and acidification, negative results (below the bold lines) should be interpreted as environmentally beneficial due to offsets such as electricity production and the avoidance of virgin material use.

A second set of graphs are presented in Figures 7 to 12 which show the sum contribution from of all contributing parts of the waste management process. For example, the totals for global warming potential in Figure 7 show the sum of the contributing parts of the process in Figure 1.

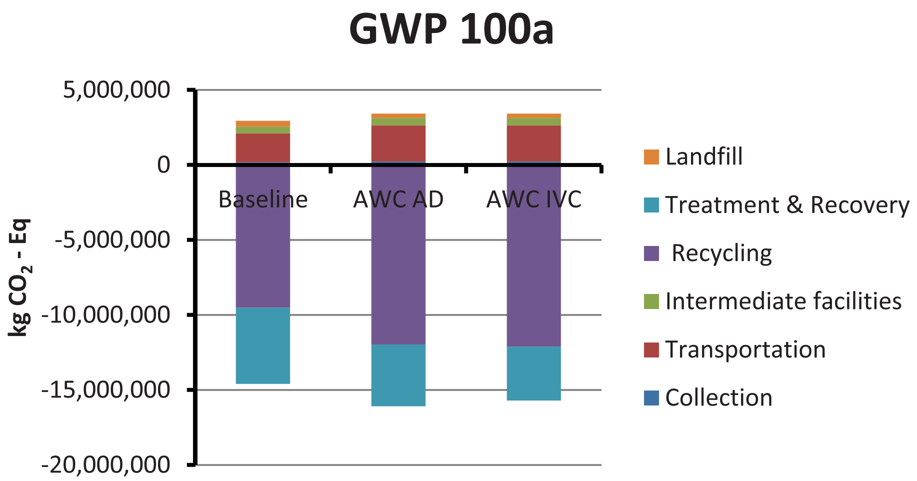


Figure 1: Breakdown of results for global warming potential

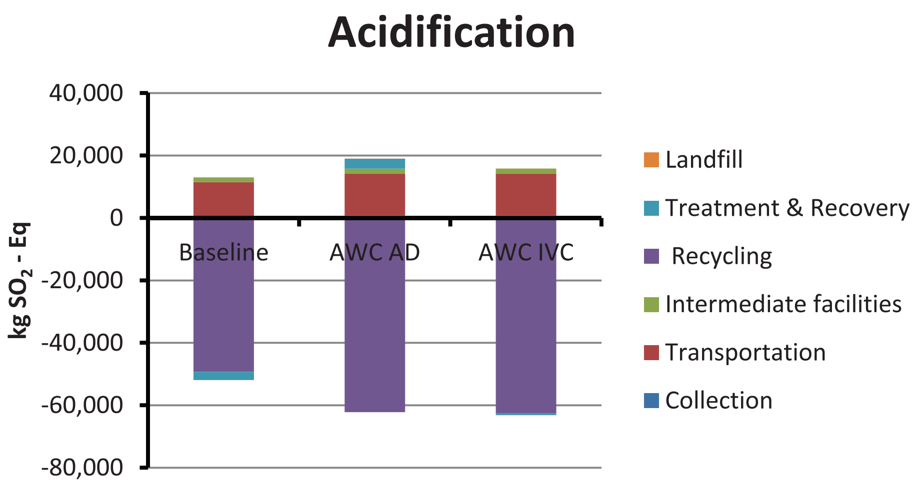


Figure 2: Breakdown of results for acidification

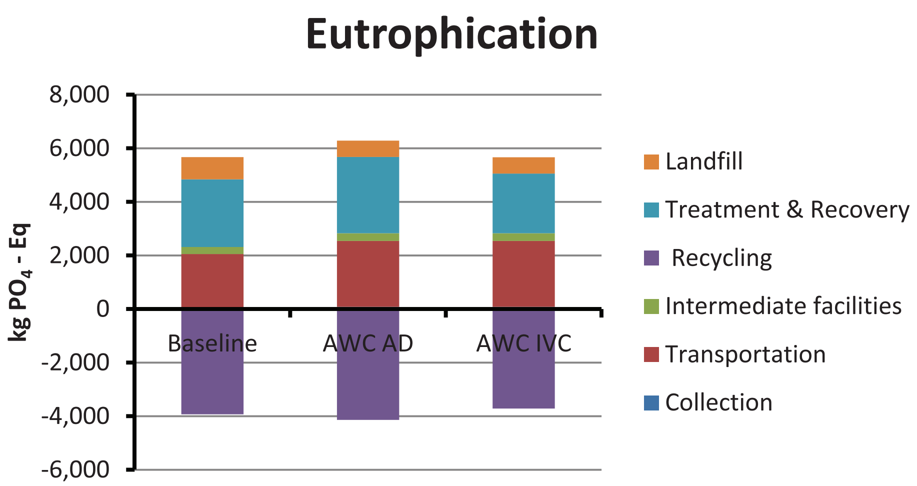


Figure 3: Breakdown of results for eutrophication

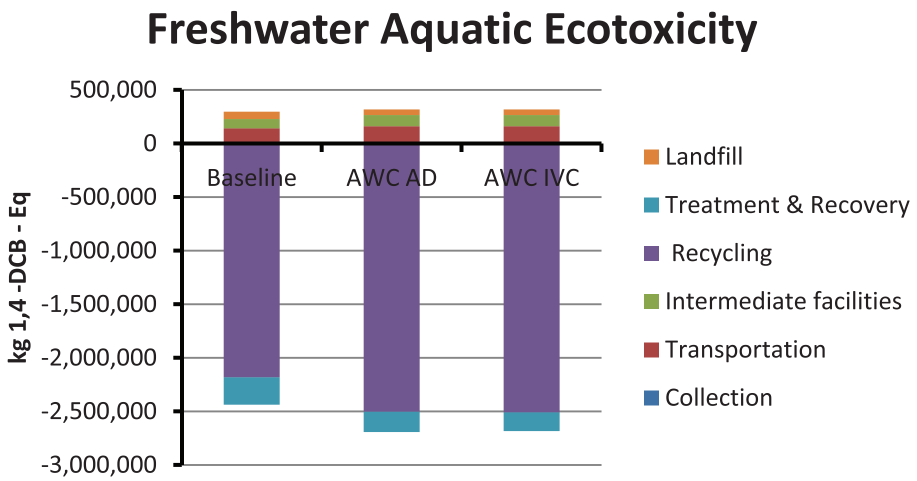


Figure 4: Breakdown of results for freshwater aquatic ecotoxicity

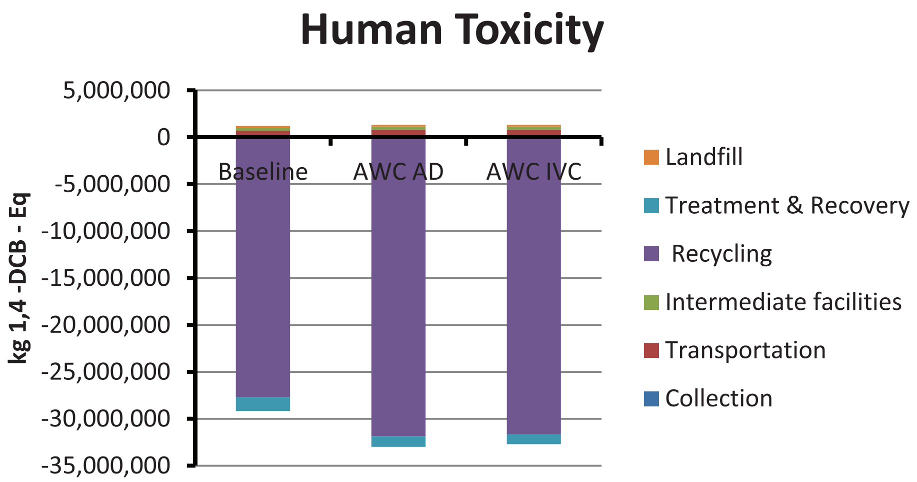


Figure 5: Breakdown of results for human toxicity

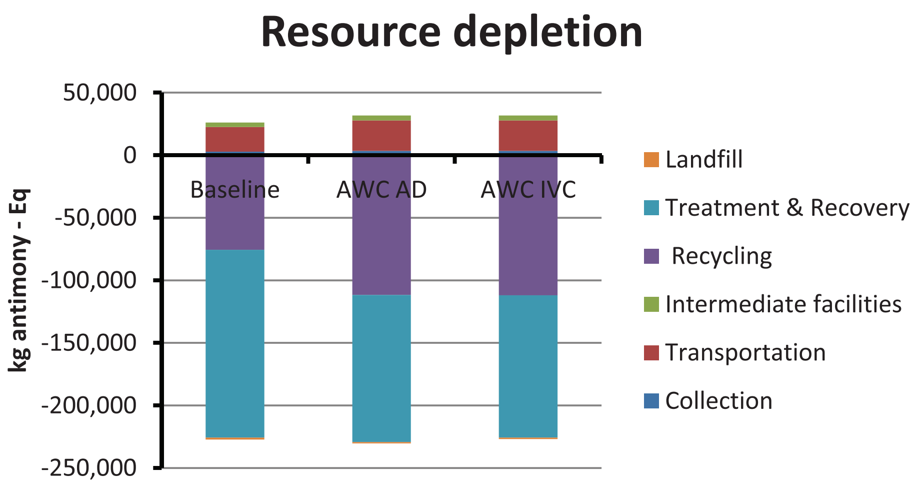


Figure 6: Breakdown of results for resource depletion

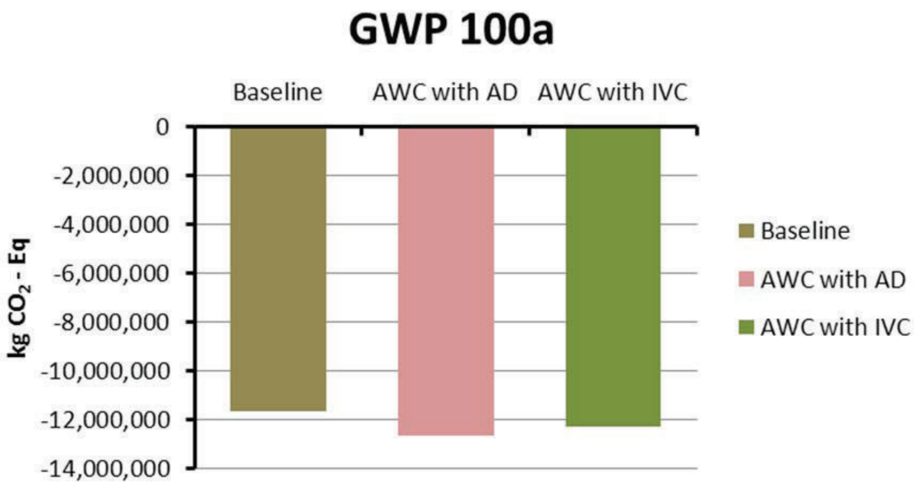


Figure 7: Total of results for global warming potential

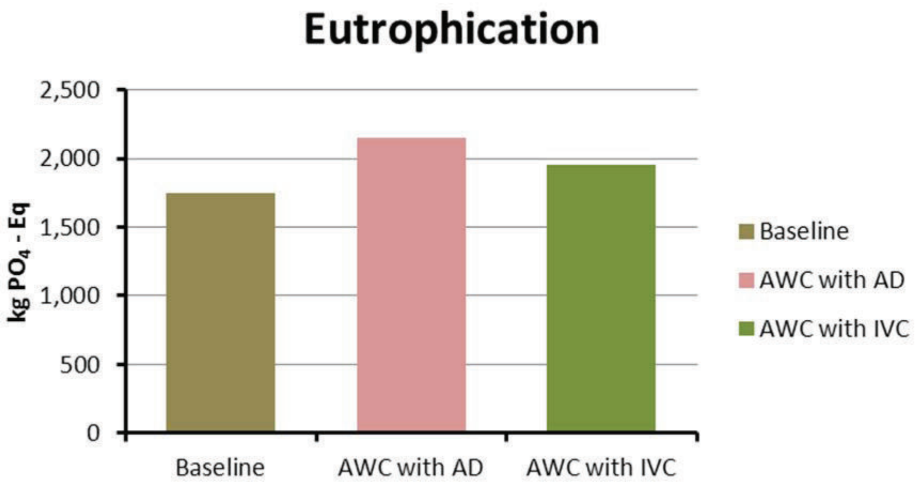


Figure 8: Total of results for eutrophication

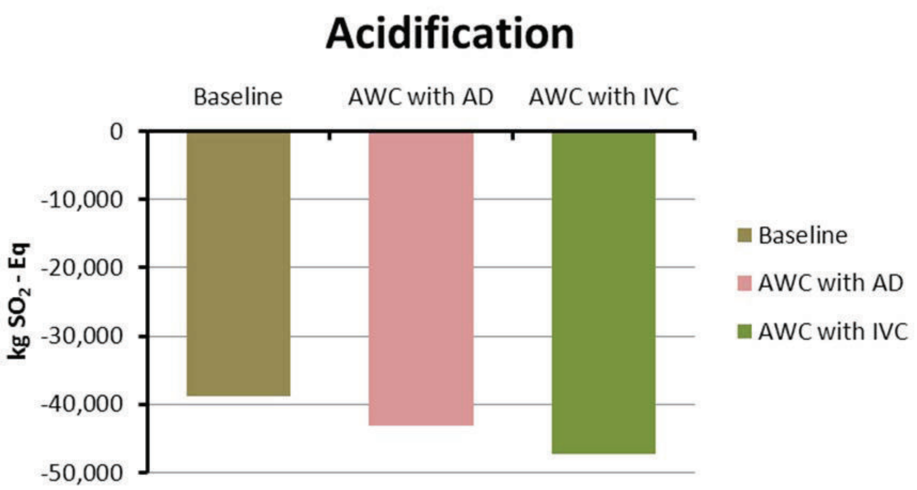


Figure 9: Total of results for acidification

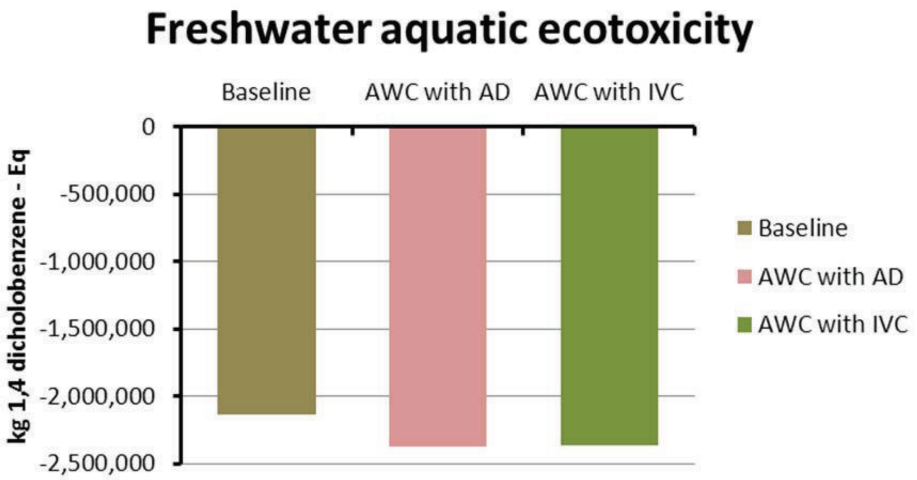


Figure 10: Total of results for freshwater aquatic ecotoxicity

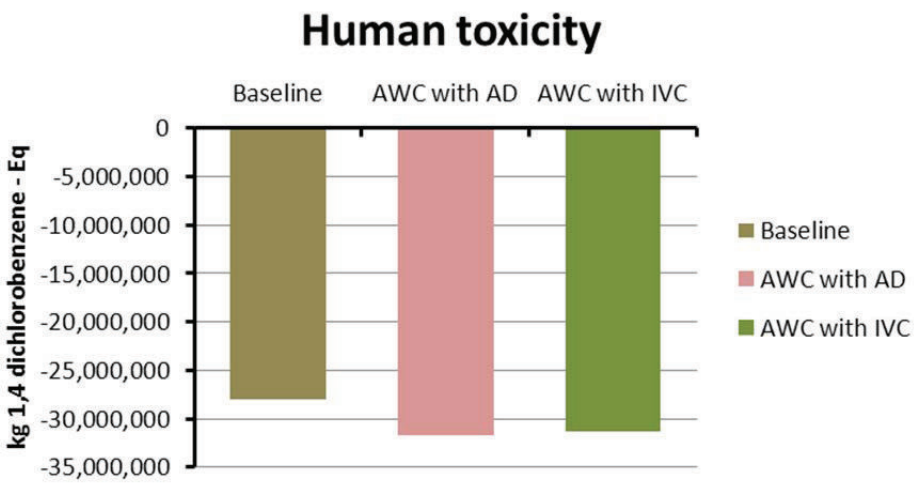


Figure 11: Total of results for human toxicity

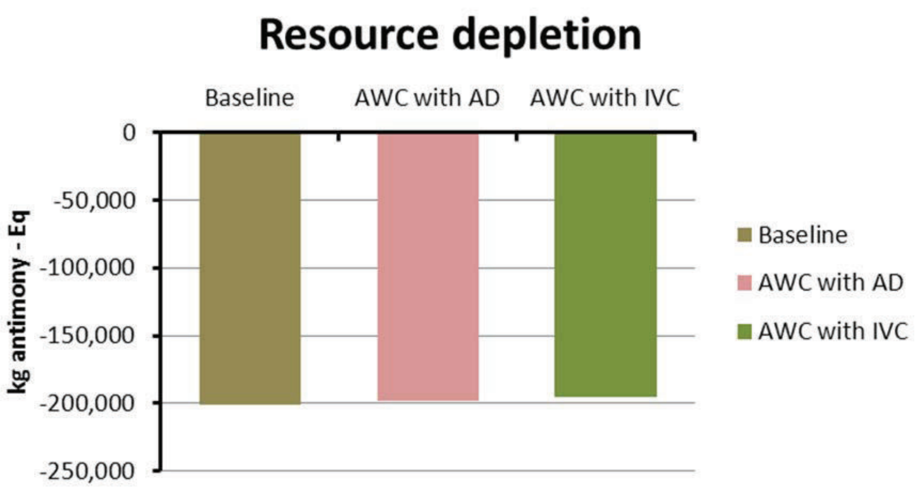


Figure 12: Total of results for resource depletion

WRATE also provides an alternative method of presenting results which uses 'European person equivalent'. To allow meaningful comparison between results, this normalises the results. Instead of presenting results in their traditional units, the normalisation allows results to all be presented as the equivalent number of 'average Europeans' which would have the same effect on the environment as this project.

For example, with reference to Table 2, the AWC with AD scenario saves the equivalent greenhouse gas emissions that 980 average Europeans would in one year, whilst the amount of resources saved would be equivalent to that used by 5,139 average Europeans. This can be seen graphically in Figure 13.

	Baseline	AWC with AD	AWC with IVC	*Units*
GWP 100a	-902	-980	-950	Eur. Person - Eq
Acidification	-543	-603	-662	Eur. Person - Eq
Eutrophication	52	64	59	Eur. Person - Eq
Freshwater aquatic ecotoxicity	-1,623	-1,801	-1,794	Eur. Person - Eq
Human toxicity	-1,415	-1,602	-1,588	Eur. Person - Eq
Resource depletion	-5,204	-5,139	-5,049	Eur. Person - Eq

Table 2: Normalised results for European person equivalent

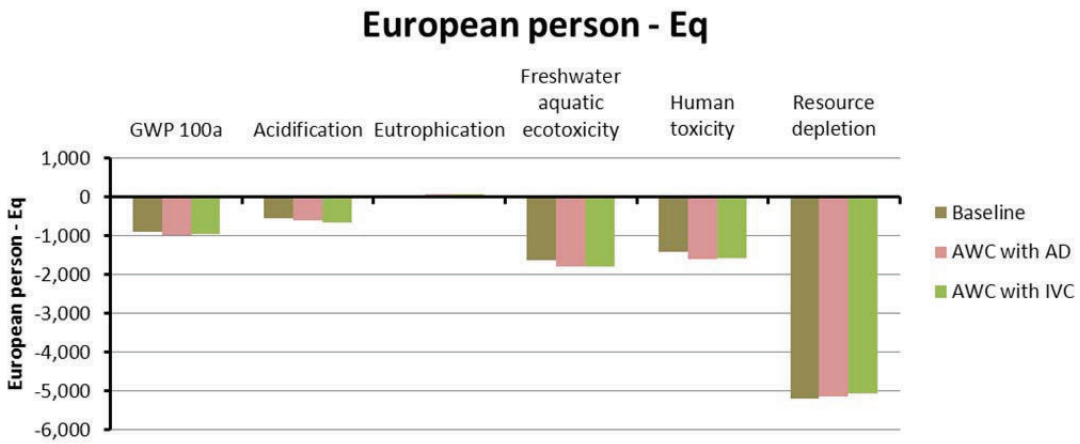


Figure 13: Normalised results for European person equivalent

7 Discussion

Comparison of the scenarios for each environmental burden is best made with reference to Figures 7 to 12. For all of the burdens the difference between scenarios is modest, with the largest difference being for acidification between the baseline and AWC with IVC (22% saving for the latter scenario). The difference between scenarios is small because the Council have already shifted away from a reliance on landfill and invested in Energy from Waste (EfW) which has some considerable offsets such as electricity production. Also, being a new facility, the Newhaven EfW is more efficient than older facilities. EfW is a major feature in all of the scenarios and this combined with fairly consistent transport use means other changes will be limited in their effect.

Global warming potential (GWP) measures the relative contribution that different greenhouse gases (GHG) make to global warming over a period of time. GWP is measured relative to carbon dioxide which is given a GWP of one. The different greenhouse gases are weighted in WRATE depending on their effect on global warming.

Figures for GWP have a timespan attached to them. This timespan is the period over which a given gas will have a certain global warming potential. A period of 100 years (100a) is most commonly used, and in this study this is the chosen time period. In this instance, moving from the baseline to AWC with IVC scenario would save 620 tonnes CO_2 (equivalent) per annum which is the equivalent to that emitted by 48 'average Europeans' (see Table 2).

The other burdens are weighted in a similar manner to GWP providing an 'equivalent' unit to work from. For example in quantifying resource depletion units are given in terms of kg of antimony. Resources contributing to this are weighted according to abundance. Figure 6 shows the breakdown of the resource depletion figures and it can be seen that recycling and the treatment/recovery components contribute the largest savings. This is due to offset virgin material use from recycling and offset fossil fuel use in electricity production. The largest component which depletes resources in all scenarios is transport. Transport is the worst performing component in all the environmental burdens with the exception of eutrophication, although the effect of the scenarios on eutrophication can be seen to be small in Figure 13.

8 Conclusions

In conclusion, based on this WRATE modelling exercise, the investment by the Council in EfW means that environmental savings from the implementation of alternate weekly residual waste collections with a weekly food collection, whether treated by AD or IVC is small although there are environmental advantages to be gained.

There is very little difference in the environmental impacts associated with treating the food waste at an AD facility or an IVC facility. Treatment of food waste via AD does perform better then IVC in terms of the following environmental burdens:

- Global warming potential
- Freshwater aquatic toxicity
- Human toxicity
- Resource depletion

In contrast, treatment of food waste via IVC performs better than AD in terms of these environmental burdens:

- Eutrophication
- Acidification

The results generated by WRATE are based upon the development of new facilities to treat the wastes modelled. As the Council already has use of an existing IVC facility ORA recommends that food waste should be processed at this facility if possible, rather than building a new AD facility as this would avoid the environmental impacts s associated with construction.

9 Appendices

Appendix A: Data used

A1. Waste composition

WRATE category	Baseline residual %	Baseline recycling %	AWC residual %	AWC recycling %
Paper and Card:				
Newspapers	3.73	39.48	0.92	36.44
Magazines	0.44	2.82	0.59	2.15
Recyclable paper	3.96	8.69	4.15	8.43
Other paper	3.73	2.54	5.02	1.92
Card packaging	2.92	9.86	2.89	9.12
Plastic film:				
Bags	2.89	0.37	3.89	0.27
Other plastic film	4.20	0.25	5.67	0.19
Dense plastic:				
Drinks bottles	0.60	2.42	0.53	2.28
Other bottles	0.66	2.20	0.62	2.08
Other dense plastic	5.69	0.53	2.41	8.39
Textiles:				
Unspecified textiles	3.47	0.08	4.65	0.06
Absorbent hygiene products:				
Disposable nappies	4.58	0.00	6.17	0.00
Other	0.41	0.00	0.56	0.00
Wood:				
Non-packaging wood	0.57	0.00	0.77	0.00
Combustibles:				
Unspecified Combustibles	2.96	0.00	3.99	0.00
Shoes	0.20	0.00	0.27	0.00
Other Combustibles	1.30	0.06	1.76	0.05
Non-combustibles:				
Unspecified non-combustibles	3.25	0.09	4.39	0.07
Soil	1.05	0.00	1.41	0.00
Glass:				
Non-packaging glass	0.77	0.10	1.04	0.07
Green bottles	0.82	12.77	0.27	11.03

WRATE category	Baseline residual %	Baseline recycling %	AWC residual %	AWC recycling %
Clear bottles	1.95	11.65	1.40	10.77
Brown bottles	0.24	2.05	0.18	1.78
Organic:				
Garden waste	7.59	0.06	10.22	0.05
Food waste	34.86	0.01	27.77	0.00
Organic pet bedding/litter	0.84	0.00	1.13	0.00
Other organics	0.66	0.00	0.89	0.01
Ferrous metals:				
Steel food and drink cans	1.26	3.04	1.29	2.95
Other ferrous metal	0.49	0.02	0.66	0.01
Non-ferrous metals:				
Aluminium drinks cans	0.29	0.77	0.31	0.71
Foil	0.74	0.01	0.31	1.05
Other non-ferrous metal	0.39	0.03	0.51	0.02
Fine material (<10mm):				
Unspecified fine material	0.86	0.00	1.16	0.00
Waste electrical and electronic equipment:				
Unspecified WEEE	0.86	0.01	1.16	0.01
Other WEEE	0.02	0.00	0.03	0.00
Specific hazardous household:				
Unspecified hazardous	0.08	0.00	0.11	0.00
Batteries	0.08	0.09	0.10	0.09
Paint/varnish	0.54	0.00	0.73	0.00
Oil	0.05	0.00	0.07	0.00

A2. Bin size distribution

Residual bin sizes were distributed according to the Council's bin size audit. For residual waste this is 140 litres – 82.7%, 240 litres – 16.7% and 360 litres – 0.6%. Two recycling bins were allocated to each of the 80,000 households (dry recyclables + glass). For food waste an additional two bins were allocated to each household (one internal, one external). WRATE does not have an allowance for external food waste bins and so a pair of internal ones were selected.

A3. Transportation

Transport	Distance (A-B unless stated) km
Baseline residual collection	110,448 (per annum)
Baseline recycling collection	64,688 (per annum)
Transfer station to Newhaven EfW	24
Transfer station to Lidsey landfill	50
Train EfW to bottom ash processer	112
EfW to ferrous processor	10
MRF plastics to Dagenham	111
MRF plastics to South Normanton	320
MRF glass to Bromley	94
MRF glass to South Kirkby	388
MRF ferrous to Pontypool	308
MRF ferrous to Llanelli	397
MRF ferrous to Port Talbot	361
MRF ferrous to Lewes	13
MRF non-ferrous to Swindon	206
MRF non-ferrous to Warrington	408
MRF non-ferrous to Birmingham	284
MRF paper to Shotton	438
MRF paper to Aylesford	101
MRF card to Newhaven	24
MRF card to Snodland	97
AWC residual collection	55,224 (per annum)
AWC recycling collection	64,688 (per annum)
AWC food waste collection	110,448 (per annum)
Transfer station to IVC/AD	36

A4. Treatment, recovery and disposal

EfW: Gross electrical efficiency: 29%
Gas cleaning system: dry
Reduction type: SNCR

AD: Wet

IVC: Forced aeration producing ABRP compliant, PAS100 compost.

Landfill: Details unknown, although clay liner, clay cap selected.

Appendix B: Waste composition categories

WRATE category	Brighton & Hove audit category
Paper and Card:	
Newspapers	Newsprint grade paper
Magazines	Catalogues
Recyclable paper	Household paper
Other paper	Yellow pages Non-recyclable but compostable paper Non-recyclable non-compostable paper
Card packaging	Corrugated card Flat card
Plastic film:	
Bags	Refuse sacks Carrier bags
Other plastic film	All other plastic film
Dense plastic:	
Drinks bottles	PET bottles
Other bottles	HDPE bottles PVC bottles
Other dense plastic	All other dense plastic
Textiles:	
Unspecified textiles	Potentially recyclable / reusable textiles Cleaning textiles / rags
Absorbent hygiene products:	
Disposable nappies	Nappies
Other	Other sanitary
Wood:	
Non-packaging wood	Wood Wood composite
Combustibles:	
Unspecified Combustibles	Pet excrement (not bedding)
Shoes	Shoes
Other Combustibles	Composite packaging (predominantly card) Composite packaging (predominantly not card)
Non-combustibles:	
Unspecified non-combustibles	Other items suitable for reuse Miscellaneous
Soil	Garden soil and pot plants
Glass:	
Non-packaging glass	Non-recyclable glass
Green bottles	Green
Clear bottles	Clear

WRATE category	Brighton & Hove audit category
Brown bottles	Brown
Organic:	
Garden waste	Garden woody organic Garden other organic
Food waste	Kitchen home compostable Kitchen other organics
Organic pet bedding/litter	Pet bedding
Other organics	Liquid foodstuffs
Ferrous metals:	
Steel food and drink cans	Ferrous cans and packaging
Other ferrous metal	Other ferrous metals
Non-ferrous metals:	
Aluminium drinks cans	Aluminium cans
Foil	Aluminium foil
Other non-ferrous metal	Other non-ferrous metals Aerosols
Fine material (<10mm):	
Unspecified fine material	Fines
Waste electrical and electronic equipment:	
Unspecified WEEE	All WEEE categories
Other WEEE	Fluorescent tubes and low energy/energy efficient light bulbs
Specific hazardous household:	
Unspecified hazardous	Non-recyclable – cleaners and other chemicals, clinical, asbestos
Batteries	Batteries
Paint/varnish	Paint and related products
Oil	Cooking oil Mineral oil

Appendix C - Tabulated results

	GWP 100a (kg CO_2 - Eq)						
	Collection	Transportation	Intermediate facilities	Recycling	Treatment & Recovery	Landfill	**Total**
Baseline	178,513	1,938,260	433,273	-9,522,887	-5,074,174	390,465	**-11,656,550**
AWC AD	223,626	2,419,609	486,038	-11,974,576	-4,113,786	295,644	**-12,663,445**
AWC IVC	223,626	2,419,609	486,038	-12,106,689	-3,595,144	295,644	**-12,276,916**

Results of LCA – Global Warming Potential

	Acidification (kg SO_2 - Eq)						
	Collection	Transportation	Intermediate facilities	Recycling	Treatment & Recovery	Landfill	**Total**
Baseline	611	10,871	1,505	-49,247	-2,643	44	**-38,859**
AWC AD	779	13,411	1,632	-62,190	3,166	31	**-43,171**
AWC IVC	779	13,411	1,632	-62,495	-682	31	**-47,324**

Results of LCA – Acidification

	Eutrophication (kg PO_4 - Eq)						
	Collection	Transportation	Intermediate facilities	Recycling	Treatment & Recovery	Landfill	**Total**
Baseline	61	1,995	260	-3,929	2,527	831	**1,745**
AWC AD	82	2,465	285	-4,140	2,846	610	**2,148**
AWC IVC	82	2,465	285	-3,712	2,228	610	**1,958**

Results of LCA – Eutrophication

	Freshwater Aquatic Ecotoxicity (kg 1,4 -DCB - Eq)						
	Collection	Transportation	Intermediate facilities	Recycling	Treatment & Recovery	Landfill	**Total**
Baseline	12,397	129,115	87,685	-2,182,827	-255,111	68,624	**-2,140,117**
AWC AD	12,841	149,168	104,048	-2,502,997	-190,295	52,540	**-2,374,695**
AWC IVC	12,841	149,168	104,048	-2,508,852	-175,507	52,540	**-2,365,762**

Results of LCA – Freshwater aquatic ecotoxicity

	Human Toxicity (kg 1,4 -DCB - Eq)						
	Collection	Transportation	Intermediate facilities	Recycling	Treatment & Recovery	Landfill	**Total**
Baseline	43,863	663,853	278,365	-27,700,898	-1,471,718	220,547	**-27,965,988**
AWC AD	47,787	772,039	328,145	-31,843,205	-1,139,935	168,476	**-31,666,693**
AWC IVC	47,787	772,039	328,145	-31,656,906	-1,042,351	168,476	**-31,382,810**

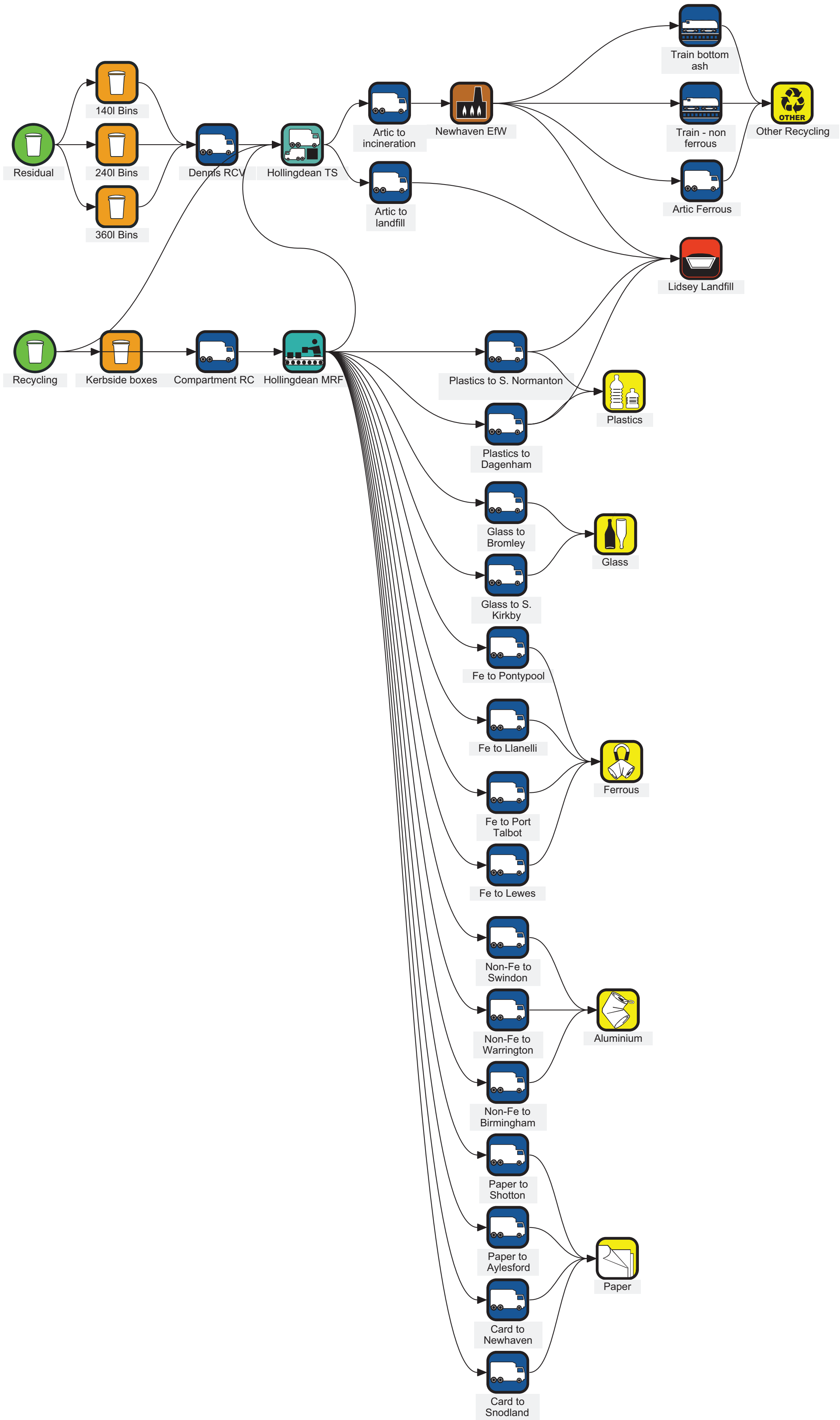
Results of LCA – Human toxicity

	Resource depletion (kg antimony - Eq)						
	Collection	Transportation	Intermediate facilities	Recycling	Treatment & Recovery	Landfill	**Total**
Baseline	2,777	19,701	3,645	-75,655	-150,082	-1,484	**-201,098**
AWC AD	3,482	24,306	3,983	-111,684	-117,549	-1,122	**-198,584**
AWC IVC	3,482	24,306	3,983	-111,939	-113,810	-1,122	**-195,100**

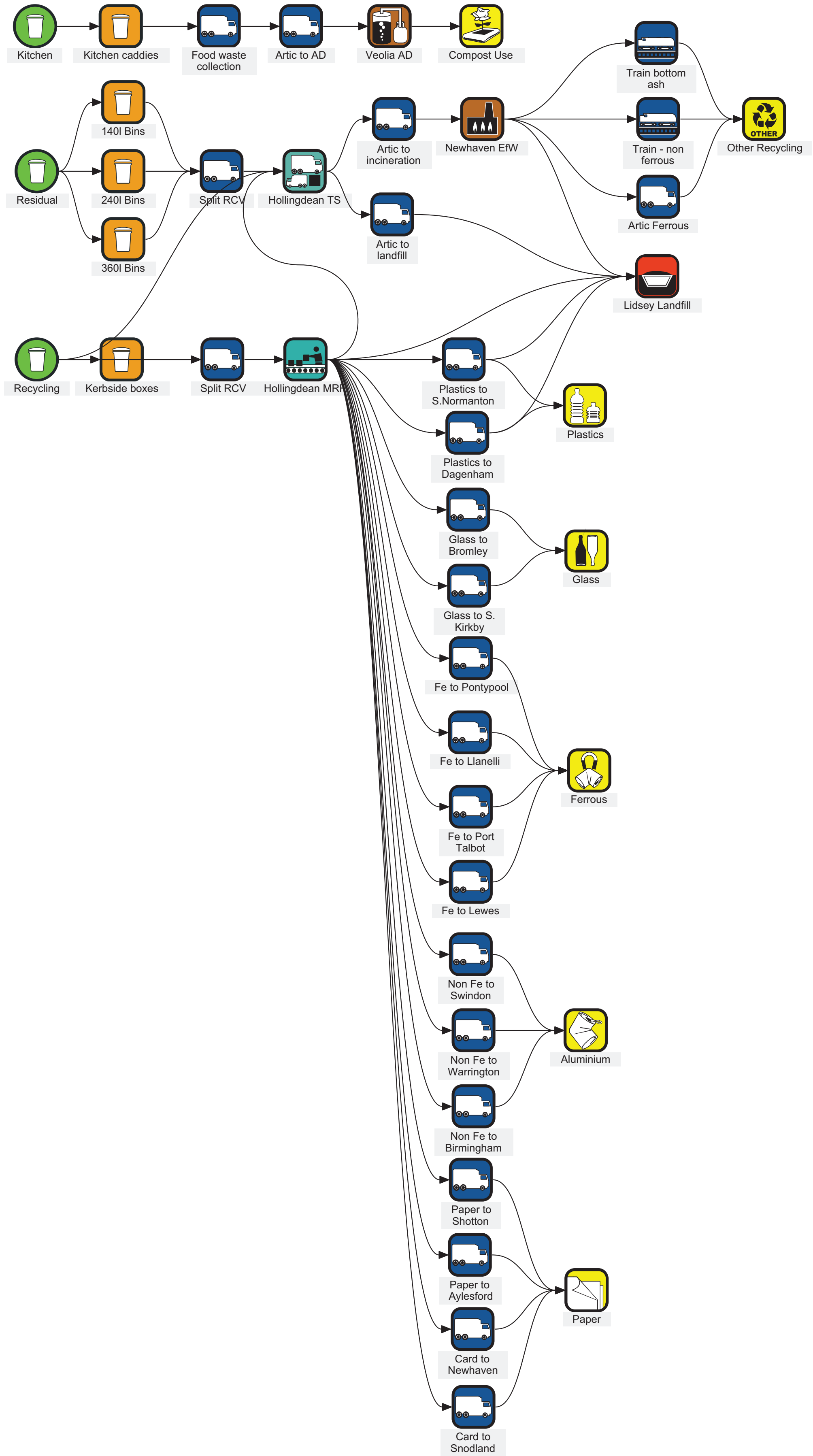
Results of LCA – Resource depletion

Appendix D - Scenario maps

Main Brighton Baseline
Printed: 25-10-2011 11:22

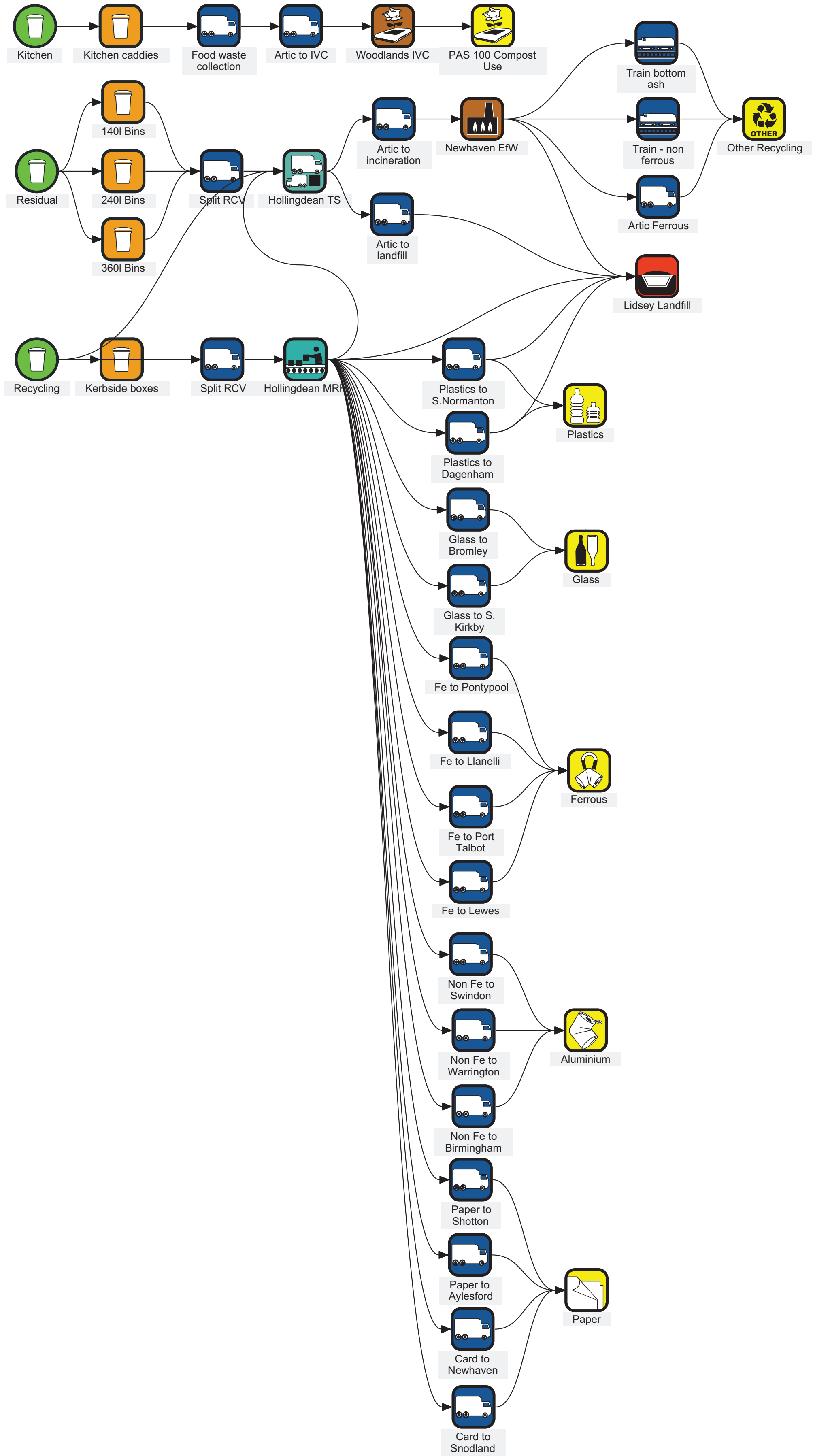


Software Version and build date: V2.0.1.4_09-04-2010
Database Version and build date: V2.0.1.4_09-04-2010
Last project modification date: 25-10-2011



Software Version and build date: V2.0.1.4_09-04-2010
Database Version and build date: V2.0.1.4_09-04-2010
Last project modification date: 25-10-2011

Main Brighton AWCs
Printed: 25-10-2011 11:21



Software Version and build date: V2.0.1.4_09-04-2010
Database Version and build date: V2.0.1.4_09-04-2010
Last project modification date: 25-10-2011