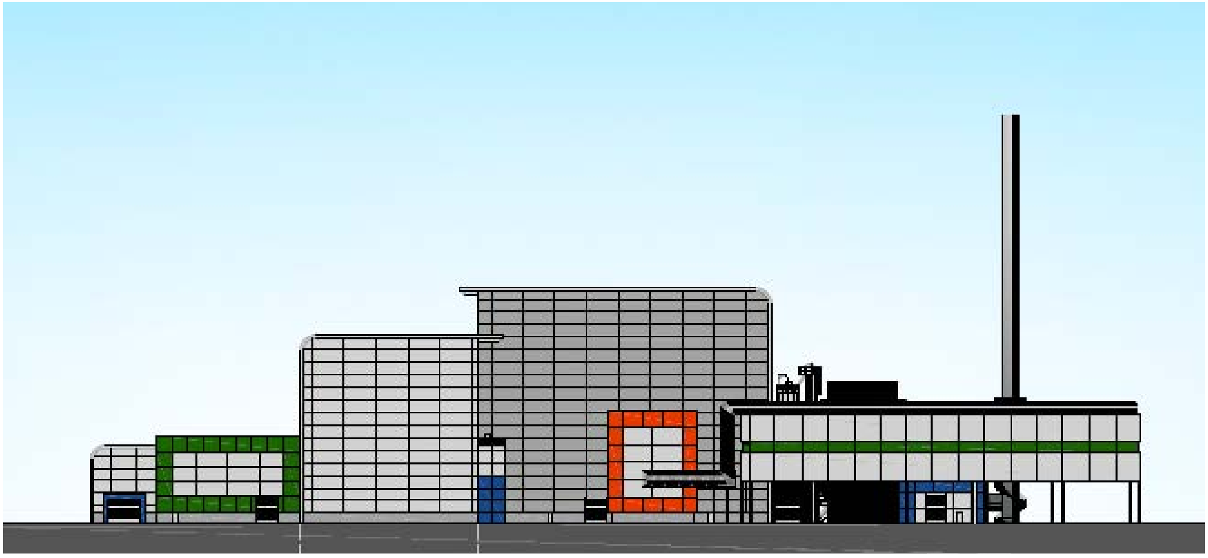
WRATE Model

Supporting Information



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Figures and Tables

1 Introduction

The following describes modelling carried out using WRATE (waste and resources assessment tool for the environment) version 2.0.1.4 to complete a scenario for the proposed solution. Outputs from the model will be applied as part of the CFT Bid Evaluation process in the procurement for the South West Devon Residual Waste Treatment and Disposal Contract.

We confirm that the modelling carried out is in full compliance with guidance provided in the document *SWDWP Instruction to Tenderers - CFT Appendix 6 – WRATE Instructions* and that it fairly and accurately represents the proposed solution. Assumptions contained in the scenario are consistent with information provided elsewhere in the bid.

This document includes an explanation of the WRATE assessment carried out and assumptions applied, supporting the submitted WRATE project file reference *SWDWP_CFT_WRATE_MVV_Solution.lca*. The submitted WRATE project file contains two scenarios relating to the baseline (as provided) and proposed solutions. We confirm that all pre-defined assumptions relating to Project Year, waste tonnages, composition and electricity mix have been fully retained.

The proposed solution incorporates a user defined process (UDP) to most realistically represent the forecast performance of the proposed thermal treatment facility. Our approach to create the UDP follows recognised LCA best practice to duplicate an existing process, use this as a ‘surrogate’ and edit parameters where new data are available. This is the approach advocated by the Environment Agency and disseminated to WRATE users through expert level training. The UDP has been independently peer reviewed and the peer review report is submitted (*02 Review of WRATE UDP (Devon MVV EfW plant)*) together with a further document confirming allocation data in the reviewed process (*02 Review of WRATE UDP (Devon MVV EfW plant) Annex 1*).

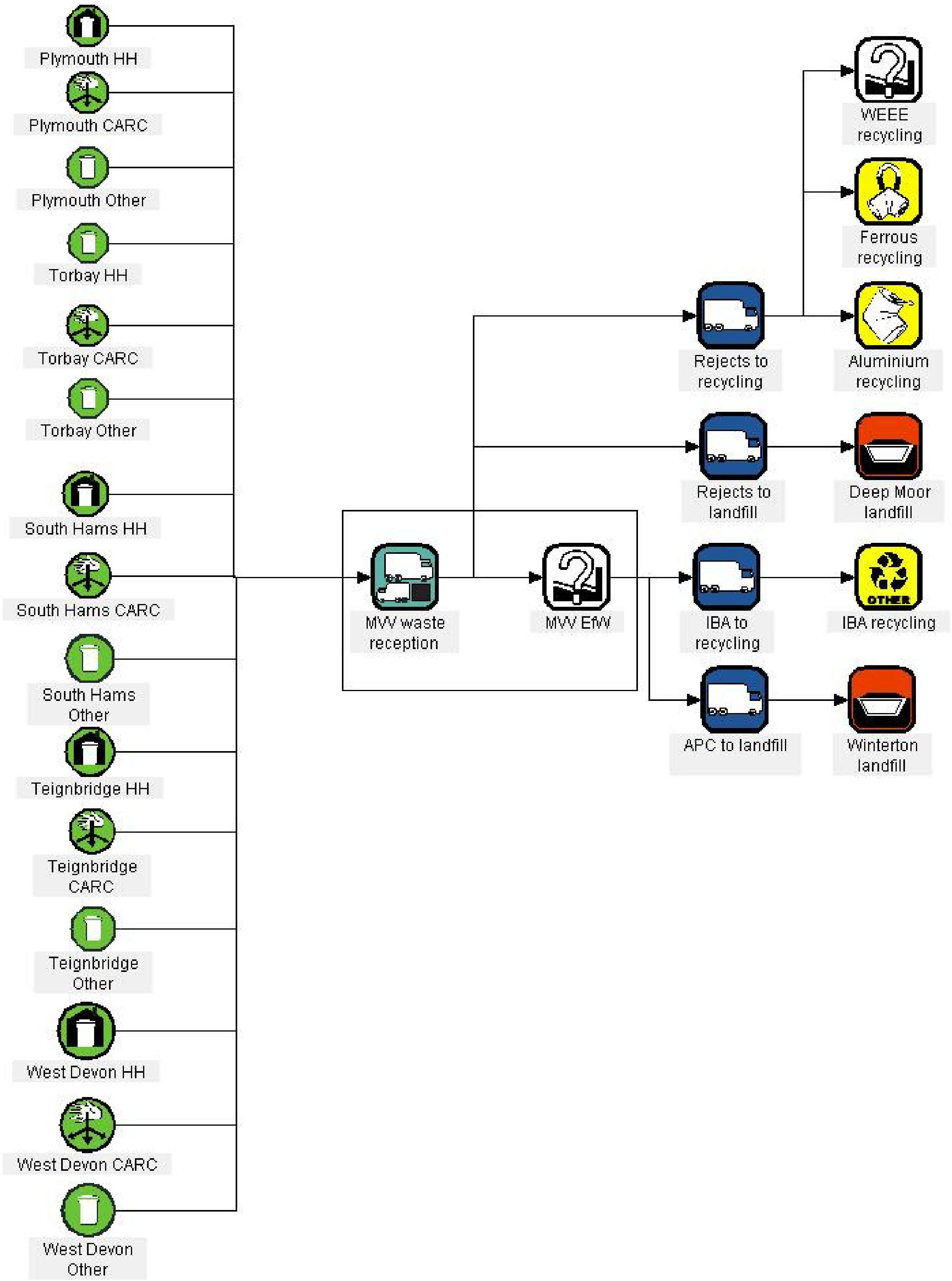
Table numbers applied in this document reflect the numbers assigned in *SWDWP Instruction to Tenderers - CFT Appendix 6 – WRATE Instructions* where template tables were provided. Additional tables are provided to describe the scenario in more detail as appropriate.

2 Description of WRATE scenario modelled

The proposed solution is modelled using the baseline scenario provided, which is based on Contract Waste as described in *SWDWP Instruction to Tenderers - CFT Appendix 6 – WRATE Instructions*. We confirm that no additional commercial and industrial waste streams have been added to the modelled project waste. Following the Authority’s guidance, the assumptions underlying the scenario modelling are consistent with the waste flow model (please refer to Method Statement 3) and any discrepancies are listed in this report.

The WRATE scenario diagram for the proposed solution is provided in Figure 1.

Figure 1: WRATE scenario diagram



Contract Waste composition

Although Contract Waste tonnage is identical in the waste flow model and WRATE baseline data, the Contract Waste composition is slightly in variance. We confirm that the baseline composition has been retained in the WRATE model submitted, however variance in composition with the waste flow model means that despite our best efforts to exactly match the WRATE model to waste flow model assumptions there will inevitably be marginal differences in tonnages of specific materials managed within the solution. Table 1 illustrates the differences in Contract Waste composition between the models.

Table 1: Variation in Contract Waste composition

Material	**WRATE composition**		**Waste flow model composition**	
	Tonnage	**%**	**Tonnage**	**%**
Paper and card	29,147.3	16.77%	30,761.82	17.69%
Plastic film (2D plastic)	9,028.17	5.19%	10,965.26	6.31%
Dense plastic (3D plastic)	14,828.1	8.53%	13,938.73	8.02%
Textiles	5,381.16	3.10%	7,280.78	4.19%
Absorbent hygiene products	5,865.46	3.37%	7,933.00	4.56%
Wood	6,081.81	3.50%	3,948.25	2.27%
Combustibles	11,504.2	6.62%	7,598.39	4.37%
Multi layer items	N/A	N/A	1,530.47	0.88%
Non-combustibles	5,210	3.00%	14,277.02	8.21%
Glass	5,972.72	3.44%	9,147.02	5.26%
Organic	58,231.9	33.49%	57,054.38*	32.82%
Ferrous metal	4,561.69	2.62%	4,376.96	2.52%
Non-ferrous metal	1,341.83	0.77%	1,408.03	0.81%
Fine material <10mm	7,745.24	4.45%	N/A	N/A
Waste electrical and electronic equipment	2,951.15	1.70%	2,192.49	1.26%
Specific hazardous household	6,005.15	3.45%	1,443.41	0.83%
Total	**173,856.00**	**100.00%**	**173,856.00**	**100.00%**

* Combined kitchen organics (23.93%) and garden organics (8.89%)

Waste arisings

The MVV EfW facility (Postcode: PL2 2BG) is located within the Partnership's boundary and therefore according to the guidance it has been assumed that waste arises at the EfW site.

Intermediate facilities

A waste transfer station has been included for scenario modelling to enable sorting of reject materials from the facility, either for disposal or recycling. Table 2 describes application of this facility.

Table 2: (based on Table B.1) – Intermediate Facilities Information

Facility	WRATE Technology	Capacity	Distribution from Facility	Justification
MVV waste reception	Transfer Station (Road) ID: 12246	Nominal capacity 175Ktpa; input 173,856tpa	97.7% to MVV EfW; 0.71% rejects to landfill and 1.6% rejects to recycling*	Enables accurate sorting of materials as rejects and recycling in-line with the waste flow model

* The waste flow model assumes 0.28% reject to recycling. In the WRATE model additional 2,180tpa ferrous metal and 132.33tpa non-ferrous metal are recovered from the intermediate process to ensure metals recycling across the whole solution matches waste flow model assumptions. Refer to metal recycling description for further detail.

Excluded waste (reject) from the facility

The waste flow model assumes 1,700 tonnes Contract Waste will be excluded from the facility as reject for landfill disposal or recycling. This material comprises defined percentages of six material categories. In line with the waste flow model, ferrous metals, non-ferrous metals, HHW, WEEE, miscellaneous combustibles and miscellaneous non-combustibles were selected as rejects in the WRATE scenario.

As described in Table 1, the tonnages of these materials vary between the waste flow model and WRATE compositions. To complete the WRATE scenario the percentage of each excluded material, as described in the waste flow model, was applied. The result of this and any resulting variance between WRATE and the waste flow model is shown in Table 3.

Table 3 shows, based of the approach outlined above, the tonnage of excluded material in the WRATE scenario (1,705.3tpa) closely matches the waste flow model assumption (1,700tpa). In terms of composition, the excluded materials to landfill and recycling vary as an inevitable consequence of the composition variation reported in Table 1.

Table 3: Waste flow model and WRATE model assumptions for rejects

TOTAL Excluded waste	**Waste flow model**		**WRATE scenario**	
	Tonnes	**%**	**Tonnes**	**%**
Ferrous metals	184	4.20%	191.77	4.20%
Non Ferrous metal	47	3.34%	44.79	3.34%
HHW	113	7.83%	470.13	7.83%
WEEE	175	7.98%	235.55	7.98%
Miscellaneous combustible	289	3.80%	437.56	3.80%
Miscellaneous non combustible	892	6.25%	325.51	6.25%
Total	**1,700**		**1,705.30**	
Excluded waste recycled	**Waste flow model**		**WRATE scenario**	
	Tonnes	**%**	**Tonnes**	**%**
Ferrous metals	184	100%	191.77	100%
Non Ferrous metal	47	100%	44.79	100%
HHW	57	50%	0	0%*
WEEE	175	100%	235.55	100%
Miscellaneous combustible	0	0%	0	0%
Miscellaneous non combustible	0	0%	0	0%
Sub-total	**462**		**472.11**	
Excluded waste to landfill	**Waste flow model**		**WRATE scenario**	
	Tonnes	**%**	**Tonnes**	**%**
Ferrous metals	0	0.00%	0	0%
Non Ferrous metal	0	0.00%	0	0%
HHW	57	50%	470.13	100%*
WEEE	0	0.00%	0	0%
Miscellaneous combustible	289	100%	437.56	100%
Miscellaneous non combustible	892	100%	325.51	100%
Sub-total	**1,238**		**1,233.19**	

* 100% of excluded hazardous household waste is assumed disposed to landfill as there is no WRATE recycling process to manage this material.

Transport assumptions

Following the Authority's guidance the transport of Contract Waste to the facility has been excluded as the site is within the Authority's boundary. The transport of reject and residues are included in the WRATE scenario modelling and is consistent with the Authority's guidance.

Recycled reject (ferrous metals, non-ferrous metals and WEEE) is routed to the IBA recycling facility (Gilpins Demolition TQ11 0DQ) in-line with assumptions in the wider bid documentation. A-B distances for road transportation were calculated using Google maps.

The intermodal road transport process is selected as the most appropriate default process to represent a bulk transfer vehicle. The default capacity (17.6t) is applied; this is consistent with the waste flow model but represents a relatively conservative assumption as it is anticipated 20t loads are achievable. The default mileage composition (percentage rural/ urban/ motorway) is also retained for all journeys except transportation of APC residues. APC residues are transferred to landfill (WRG Winterton, DN15 9AP) via treatment (WRG

Knostrop, LS9 0PJ), following a predominantly motorway route therefore an amended mileage composition is adopted. All transport assumptions are detailed in Table 4.

Table 4: (based on Table B.2) – Transport Assumptions

Vehicle Movement	WRATE Technology	Post Codes		A-B (km)	Mileage Composition		
		Start	End		Rural	Urban	MWay
Rejects recycled	Intermodal road transport - v2 (12026)	PL2 2BG	TQ11 0DQ	29.5	43.32	10.4	46.28
Rejects Landfill	As above	PL2 2BG	EX38 7JA	84.7	43.32	10.4	46.28
IBA to recycling	As above	PL2 2BG	TQ11 0DQ	29.5	43.32	10.4	46.28
APC to landfill	As above	PL2 2BG	DN15 9AP	618.6	10	10	80

Treatment residues

Incinerator bottom ash (IBA) will be transported to reprocessing (Gilpins Demolition, Plymouth Road, Lower Dean, Buckfastleigh, Devon TQ11 0DQ). 90% of ferrous metal and 70% of non-ferrous metal will be recycled.

APC residues will be sent to the WRG treatment facility at Knostrop near Leeds for processing. The treated material will then either be routed to disposal at the WRG hazardous waste landfill facility at Winterton, Lincolnshire if it remains classified hazardous or the WRG non-hazardous landfill facility at Wakefield, Yorkshire WF6 2JA if it is classified as non-hazardous waste following treatment. WRATE does not include a default process for APC residue treatment therefore no process has been included in the scenario. In the absence of this process it is assumed that 100% APC residues will complete the full journey to landfill disposal.

In WRATE we have assumed 100% APC residues will be transported to Winterton Landfill via Knostrop; this is a conservative assumption as this journey (A-B 618.6km) is 74.9km longer than the journey to non-hazardous landfill (543.7km).

Metal recycling

Assumptions relating to metals recycling have the potential to significantly impact WRATE results. It is anticipated 90% ferrous metals will be recovered from IBA during processing. Non-ferrous recovery performance is anticipated to equate to 70% of non-ferrous input to the EfW process. Importantly this does not equate to 70% non-ferrous metal recovery from IBA as 5% non-ferrous metal is lost in thermal treatment through volatilization.

The bespoke WRATE IBA recycling with ferrous and non-ferrous recovery process was selected as the most appropriate process to complete the scenario. Review of this process confirmed the default assumptions result in a relatively significant underestimate of the tonnage of ferrous and non-ferrous metals recycled. The default assumptions are that 80% ferrous metal and 70% non-ferrous metal are recovered from IBA. Due to this discrepancy the tonnages of metals recovered in the scenario required correction.

As such, the 'MVV waste reception' process (WRATE bespoke transfer station process) was used to capture additional ferrous and non-ferrous metals to increase the total recovered consistent with anticipated recovery performance. This is essential as WRATE results are relatively sensitive to the quantity of metals recycled and this approach allows the metals recycling performance of the solution to be represented in-line with the relevant method statements. Summaries of the modelled ferrous and non-ferrous metal recycling performance are provided in Table 5 and Table 6 respectively.

Table 5: Ferrous metal recycling assumptions

	Ferrous metal in composition	Reject recycled (excluded waste)	Reject recycled (to correct IBA recovery)	Fe recovered from IBA	Total
Waste flow model	4,376.96 100%	184.00 4.2%	N/A	3,773.81 86%	3,957.65 90%
WRATE model	4,561.69 100%	191.77* 4.2%	2,180.33* 48%	1,752 38%	4,124.70 90%

* Total 2,372.08tpa (52%)

Table 6: Non – ferrous recycling assumptions

	Non-ferrous metal in composition	Reject recycled (excluded waste)	Reject recycled (to correct IBA recovery)	NFe recovered from IBA	Total
Waste flow model	1,408.03 100%	47 3.34%	N/A	952.72 67.66%	999.72 71%
WRATE Model	1341.83 100%	44.79 3.34%	132.33 9.86%	775 58%	952.72 71%

* Total 177.12tpa (13.2%)

3 MVV EfW user defined process (UDP)

The MVV EfW UDP is based on the default WRATE Coventry CHP process as the most appropriate to provide surrogate background data. The Coventry process is a 241Ktpa moving grate incinerator for the treatment of MSW for combined heat and power (CHP). The proposed MVV EfW facility will treat 245ktpa with electricity and heat output.

Wherever Coventry data were used, they were normalised to the MVV EfW process capacity. Surrogate data is primarily used to complete the data requirements for capital burden (construction materials) and maintenance material inputs. Other than for capital burdens and maintenance materials, the default Coventry data has been replaced wherever possible with design data for the MVV EfW process.

The energy output factors applied in the UDP is based on MVV design data and is shown in Table 7. Treatment facility distribution assumptions are shown in Table 8 and amendments to the default WRATE Coventry process shown in Table 9.

The MVV EfW UDP was independently peer reviewed, as required by the guidance. AEA Technology plc carried out the peer review, which confirmed the UDP is "suitable for use in the PFI bid". The full peer review report has been submitted to support this document.

Table 7: Energy production factors

Energy calculation	Values	Units
Waste throughput	245,000	Tonnes
Waste calorific value (CV)	9.50	MJ/Kg
Energy in waste	2,327,500,000	MJ
	646,528	MWh
Energy output (With CHP)	**MWh**	**Efficiency**
Gross Energy Produced	179,742	27.80%
Net Electricity Output	160,032	**24.75%**
Parasitic Load	19,710	3.05%
Net Heat Output	72,500	**11.21%**

Table 8: (based on Table B.3) – Treatment Facility Assumptions

Facility	WRATE Technology	Capacity	Ditsribution from Facility	Justification
MVV EfW ID: 22679	Incinerator large, heat and power Coventry - V2* ID: 13041	265,000t	100% IBA to recycling and 100% APC to landfill	Default Coventry process was selected as a large moving grate CHP facility at a similar scale to the proposed MVV EfW facility.

* The Environment Agency issued an amended UDP for the default Coventry process because the first WRATE v2 default process contained errors relating to parasitic load and CO_2 emission. This error was corrected in the applied MVV EfW UDP and this is explicitly confirmed in the peer review report submitted.

Table 9: (based on Table B.4) – WRATE user defined process amendments

Facility	WRATE Standard Technology	Justification	Reason For Amending
MVV EfW ID: 22679	Incinerator large, heat and power Coventry - V2 ID: 13041	The default WRATE process selected most closely represents the MVV EfW process in terms of maximum capacity and technology. Coventry is a large scale, mass burn moving grate incinerator for the treatment of MSW for energy generation. MVV EfW process is a conventional, proven, moving grate EfW combustion system with electricity and heat output; therefore we believe that the Coventry process is the most appropriate default process on which to base the UDP.	The default WRATE process was amended to represent the MVV EfW process. In summary the following sensitive data were amended: • The MVV process has a high efficiency system designed to maximise energy recovery. The boiler is designed to achieve much higher useful heat recovery by generating steam at higher temperatures and pressures than normally seen on EfW facilities in the UK, including the default Coventry process. MVV design data for energy recovery were applied in the UDP. • Burner start-up fuel and emissions abatement materials data were amended to reflect materials and quantities relevant to the proposed facility. • Air emissions values were also amended in the UDP to reflect monitored air emissions data from the operational MVV Leuna facility. The peer review confirmed appropriateness of this data and use of the default Coventry process emissions data as surrogate values where no measured data were available.

Alteration	Original Value	Amended Value	Data Source
1. Process Parameters			
Process Max Capacity (kg)	315,000,000	265,000,000	MVV design data
2. Headline Values			
Energy Recovered [MJ]	=([USER_TOTAL.NET_CV]*0.171)+([USER_TOTAL.NET_CV]*0.021)	=([USER_TOTAL.NET_CV]*0.2475)+([USER_TOTAL.NET_CV]*0.1121)	Based on MVV design data, see Energy Calculation

Alteration	Original Value	Amended Value	Data Source
3. Construction Material Input			
Concrete	2,600,800	2,187,975	Quantity normalised to MVV EfW max capacity: Original comment: Capital burden information taken from previous version of Wisard (Tolliday, A. Sept. 1999).
Cement	3,100	2,608	
Bricks	1,102,000	927,079	
Hardcore	4,600,000	3,869,841	
Copper	58,700	49,383	
Insulation Materials	178,000	149,746	
Refractory (Al, Si)	18,200	15,311	
Refractory (metals)	50,000	42,063	
Refractory (SiC)	17,500	14,722	
Tar	1,933,000	1,626,175	
Brass	5,500	4,627	
Steel (virgin)	6,675,000	5,615,476	
Cast Iron	175,000	147,222	
Aluminium (virgin)	67,000	56,365	
Paint	49,000	41,222	
Polyethylene (HDPE - virgin)	55,800	46,943	
4. Operational Fuel Input			
natural gas	5,764	-	REMOVED: No natural gas used for burner start-up
off-road gasoil (ULS diesel)	-	401,276.78	INSERTED: used as burner start-up, MVV data taken from Leuna EfW plant: 435,794 litres for 217,897t plant, density of oil = 0.83kg/l
ALLOCATION			
off-road gasoil (ULS diesel)	-	=([USER_WASTE_FRACTIONS_TOTAL]/[TYPICAL_WASTE_TOTAL])*[PROC_FUEL_INPUTS.OFF_ROAD_GASOIL_ULS.BURNER_START]	INSERTED: Allocation rule for diesel as burner start-up fuel

Alteration	Original Value	Amended Value	Data Source
5. Operational Material Input			
Boiler feed water chemicals - pH Control	13450	0	MVV: pH-control with sodium hydroxide and Ammonia.
Boiler feed water chemicals - Internal Treatment	17210	0	MVV process doesn’t use this as sodium hydroxide and Ammonia is sufficient for internal condition
Boiler feed water chemicals - Oxygen Scavenger	12130	0	MVV process doesn’t use this; physical treatment for oxygen scavenging
Sodium Hydroxide	73300	5214	MVV need 35kg NaOH 50% solution for 120t water = 5,214 solid 100% NaOH. Original Comment: >5% solution used for regenerating ion exchange resin in the demineralised water treatment plant.
Cooling Water Treatment Chemicals - Internal Treatment	5080	0	MVV process doesn't use cooling water
Hydrochloric Acid	76380	8,044	MVV needs 90kg HCl 30% solution for 120t water = 8044kg solid 100% HCl.
Lime	2758000	0	None
Sulphuric Acid	59500	0	MVV process doesn't use cooling water; uses air-cooled condensers
Boiler feed water chemicals - Corrosion Inhibitor	3200	0	MVV process doesn't use this material; with condition of sodium hydroxide and Ammonia an alkaline pH value is maintained which keeps a protection layer inside the boiler and prevents corrosion.
Sodium Hypochlorite	37800	0	MVV process doesn't use cooling water, have air cooled condensers.
Cooling Water Treatment Chemicals - Antifoam	10	0	MVV process doesn't use cooling water, have air cooled condensers.
Cooling Water Treatment Chemicals - Biocide	10	0	MVV process doesn't use cooling water, have air cooled condensers.
Cooling Water Treatment Chemicals - Surfactant	317	0	MVV process doesn't use cooling water, have air cooled condensers.

Alteration	Original Value	Amended Value	Data Source
Activated Carbon	19100	74,130	MVV data based on design.
Anhydrous Ammonia	0	266	MVV data based on design
Sodium Bicarbonate	0	3,664,672	MVV data: based on raw flue gas values of HCl= 900mg/Nm³ and SO2=150 mg/Nm³ (dry, 11% O2), for BiCarb with stoichiometry of 1.25 a Bicarb consumption of 15.16kg/t waste is calculated. In comparison for using of lime with these raw flue gas values we will calculate a lime consumption with stoichiometry of 2.20 of 12.1kg/t waste (2,924,969 kg for Coventry)
Urea Powder	0	344,470	MVV Data: based on 5.7kg/t of waste (25% solution)
ALLOCATION			
Anhydrous Ammonia	-	=([USER_WASTE_FRACTIONS_TOTAL]/[TYPICAL_WASTE_TOTAL])*[PROC_MATERIAL_INPUTS.ANHYDROUS_AMMONIA.UNDEFINED]	
Sodium Bicarbonate	-	=([USER_WASTE_FRACTIONS_TOTAL]/[PROCESS_PARAM.CAPACITY]*[PROC_MATERIAL_INPUTS.SODIUM_BICARBONATE.GAS_CLEAN])	
Urea Powder	-	=([USER_WASTE_FRACTIONS_TOTAL]/[TYPICAL_WASTE_TOTAL])*[PROC_MATERIAL_INPUTS.UREA_POWDER.GAS_CLEAN]	

Alteration	Original Value	Amended Value	Data Source
6. Operational water Input			
Mains Water	120,135,000	205,000,00	MVV data: based on 0.5% of boiler water = 104tph steam production x 0.5% x 8760 h x 90% availability
Surface Water	303,173,000	0	REMOVED: No surface water
Mains Water	-	14,651,000	INSERTED: based on average CHP steam extraction with 25% losses: (base 2008) = 11.15tph steam extraction *8760 h * 15% losses
7. Energy Inputs			
Electricity Grid	87,296,400	1,576,800	MVV design data
8. Process Output			
Ferrous metal	=([USER_WASTE_FRACTIONS.FERROUS_METAL]+[USER_WASTE_FRACTIONS.RDF_1_11])*0.55	-	REMOVED: All ferrous in IBA
9. Process Energy Production			
Electricity to the Grid	=[USER_TOTAL.NET_CV]*0.171	=[USER_TOTAL.NET_CV]*0.2475	MVV design data
External Heat	=[USER_TOTAL.NET_CV]*0.021	=[USER_TOTAL.NET_CV]*0.1121	MVV design data
10. Process Waste output			
Bottom Ash	([USER_TOTAL.ASH]*0.91)+(([USER_WASTE_FRACTIONS.NON_FERROUS]+[USER_WASTE_FRACTIONS.RDF_1_12])*0.05)+0.2*((([USER_WASTE_FRACTIONS.FERROUS_MET	([USER_TOTAL.ASH]*0.91)+(([USER_WASTE_FRACTIONS.NON_FERROUS]+[USER_WASTE_FRACTIONS.RDF_1_12])*0.05)+0.2*((([USER_WASTE_FRACTIONS.FERROUS_MET	Modified the factor as 100% ferrous in bottom ash

Alteration	Original Value	Amended Value	Data Source
	AL]+[USER_WASTE_FRACTIONS.RDF_1_11])*(1-0.55))+([USER_TOTAL.ASH]*0.91)+(([USER_WASTE_FRACTIONS.NON_FERROUS]+[USER_W	AL]+[USER_WASTE_FRACTIONS.RDF_1_11])*(1))+([USER_TOTAL.ASH]*0.91)+(([USER_WASTE_FRACTIONS.NON_FERROUS]+[USER_WASTE_	
Residual waste	=([USER_WASTE_FRACTIONS_TOTAL]/[TYPICAL_WASTE_TOTAL])*[PROC_WASTES.LANDFILL.RESIDUAL_WASTE.ROAD]	removed	REMOVED: No residual waste
Bottom Ash Ferrous	=([USER_WASTE_FRACTIONS.FERROUS_METAL]+[USER_WASTE_FRACTIONS.RDF_1_11])*0.45	=([USER_WASTE_FRACTIONS.FERROUS_METAL]+[USER_WASTE_FRACTIONS.RDF_1_11])*1	Modified the factor as 100% ferrous in bottom ash
14. Process Emission*			
Chromium (Cr)	11.07	7.85	MVV Leuna emissions data (0.076mg/Nm3)
Lead (Pb)	11.07	7.85	MVV Leuna emissions data (0.076mg/Nm3)
Copper (Cu)	11.07	7.85	MVV Leuna emissions data (0.076mg/Nm3)
Manganese (Mn)	11.07	7.85	MVV Leuna emissions data (0.076mg/Nm3)
Nickel (Ni)	11.07	7.85	MVV Leuna emissions data (0.076mg/Nm3)
Tin (Sn)	11.07	7.85	MVV Leuna emissions data (0.076mg/Nm3)
Cadmium (Cd)	2.00	2.02	MVV Leuna emissions data (0.0025 mg/Nm3) according to the 17. BImSchV (German WID law), accumulative measurement: Cd and Tl and their compounds
Carbon monoxide, biogenic	21,667.00	7,336.98	MVV Leuna emissions data (8.97mg/Nm3) and applying Coventry biogenic-fossil split
Hydrogen chloride	4,313.00	2,174.03	MVV Leuna emissions data (2.55 mg/Nm3).
Hydrogen fluoride	80.00	157.66	MVV Leuna emissions data (0.15 mg/Nm3)
Nitrogen oxides, NO and NO2	248,361.00	147,977.80	MVV Leuna emissions data (171.32

Alteration	Original Value	Amended Value	Data Source
as NO2			mg/Nm3)
Arsenic (As)	11.07	7.85	MVV Leuna emissions data (0.076mg/Nm3). According to the 17. BImSchV (German WID law), accumulative measurement: Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn and their compounds
Particulate matter - total	4,077.00	540.43	MVV Leuna emissions data.
VOCs	1,004.00	613.96	MVV Leuna emissions data (0.55mg/Nm3)
Carbon dioxide, fossil	99,878.63	1,334,366.16	Originating from the combustion of Diesel (gasoil) for burner start up and shut down.2.76 kg of CO2 per litre of Diesel
Water	815,039.00	-	REMOVED: No natural gas used for burner start up and shut down.
Carbon dioxide, fossil	187,623.00	-	REMOVED: Gasoil used for burner start up and shut down and its CO2 emissions is included above.
Thallium (Tl)	0.60	0.61	MVV Leuna emissions data* (0.0025 mg/Nm3) according to the 17. BImSchV (German WID law), accumulative measurement: Cd and Tl and their compounds
Antimony (Sb)	10.86	7.70	MVV Leuna emissions data (0.076mg/Nm3). According to the 17. BImSchV (German WID law), accumulative measurement: Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn and their compounds
Cobalt (Co)	12.17	8.63	MVV Leuna emissions data (0.076mg/Nm3). According to the 17. BImSchV (German WID law), accumulative measurement: Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn and their compounds
Vanadium (V)	12.17	8.63	MVV Leuna emissions data (0.076mg/Nm3). According to the 17.

Alteration	Original Value	Amended Value	Data Source
			BImSchV (German WID law), accumulative measurement: Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn and their compounds
Cadmium (Cd)	22.00	-	
Water	120,241,333.30	-	
COD	18,179.00	-	
Suspended Solids	10,882.70	-	
Water	310,000.00	-	
Carbon monoxide, fossil	8,372.00	2,834.96	MVV Leuna emissions data (8.97mg/Nm3) and applying Coventry biogenic-fossil split. Original Comment: This quantity was changed in v2 to reflect 2008 operational data. Original comment v1: Measured by CEMS equipment - direct and continuous measurement. Assumed 34:66 split between fossil: biogenic carbon
Peer Reviewed	**Date**	**Reviewer**	**Contact Details**
Yes	6 October 2010	Judith Bates	AEA group 329 Harwell Didcot Oxon OX11 0QJ t: 0870 190 6411

* Where there is reference to Leuna emissions data refer to Appendix A

4 WRATE Results

The following briefly introduces WRATE results for global warming potential over 100 years (GWP100). Results for the proposed solution are compared against the baseline landfill only solution. The proposed MVV solution results in an offsetting of -34,625 tonnes CO_2 equivalent (tCO_{2eq}) emissions. This compares to a net burden of +38,879 tCO_{2eq} from the baseline landfill only solution. Overall therefore WRATE indicates the MVV solution delivers a reduction of 73,504 tCO_{2eq} per year, equating to 1.84$MtCO_{2eq}$ emissions over the course of a 25-year contract.

The reported improvement in CO_{2eq} emissions is largely attributable (-20,387 tCO_{2eq}) to the recovery of 548,733GJ of energy per annum (based on reference year tonnages) and offset emissions from landfill disposal (-38,717 tCO_{2eq}) with an additional significant contribution from additional ferrous and non-ferrous metals recycling (-5,749 tCO_{2eq}). Transportation and intermediate facilities represent net burdens but they are essential to realise the proposed solution and deliver the net benefit.

Figure 2 represents the WRATE graphic for GWP100 to compare the performance of the proposed solution against the baseline. Normalised results showing indicative performance against all six WRATE indicators are shown in Table 10.

Figure 2: WRATE graphic: GWP100

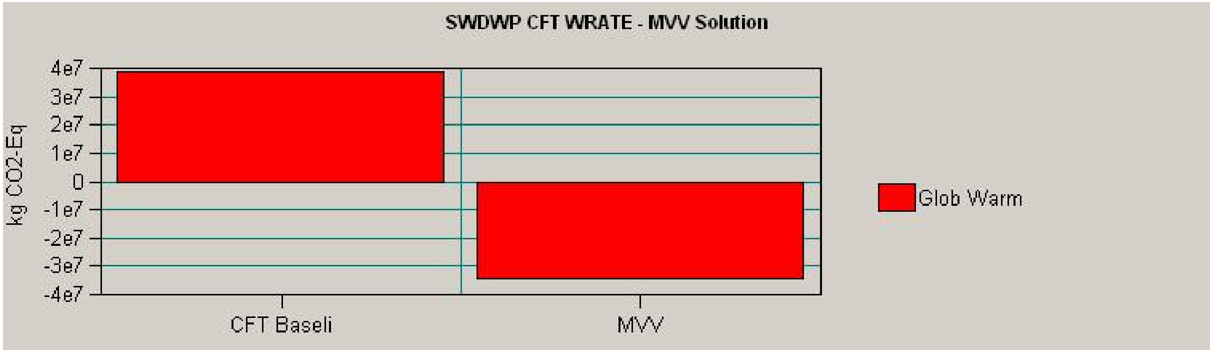


Table 10: WRATE Normalised result (Eur. Person Eq.)

WRATE impact categories	Baseline	MVV
climate change: GWP 100a	3,008	-2,679
acidification potential: average European	77	-826
eutrophication potential: generic	1,629	46
freshwater aquatic ecotoxicity: FAETP infinite	506	-4,287
human toxicity: HTP infinite	-32	-2,963
resources: depletion of abiotic resources	-3,256	-19,325
Total	**1,931**	**-30,034**

Appendix A – Leuna Emissions Data

Bericht nach § 12 (2) der 17. BImSchV TREA Leuna II — 2008

mittlere spez. Emissionen und Emissions-Frachten

	2008 **Konzentrationen** [mg/m³]	2008 **Frachten** [kg]
HCl	2,55	1.959,66
CO	8,97	9.168,94
NO2	171,32	133.386,50
SO2	39,51	31.145,08
NH3	3,24	2.535,67
Cges	0,55	553,42
Hg	0,0019	1,22
Staub	0,58	487,14
HF	0,15	142,11
§ 5 (1) Nr. 3 a)*	0,0025	2,37
§ 5 (1) Nr. 3 b)*	0,0760	72,00
§ 5 (1) Nr. 3 c)*	0,0130	12,32
PCDD/F	5,00E-10	4,74E-07

Rauchgasmenge	**Betriebszeit**
2008 [Mio Nm³]	2008 [h]
947,395	8.236

Glossary

Cges	Entire Carbon
Staub	Dust
$5 (1) Nr. 3 a)*	according to the 17. BImSchV (German WID law), accumulative measurement: Cadmium and its compounds Thallium and its compounds
$5 (1) Nr. 3 b)*	according to the 17. BImSchV (German WID law), accumulative measurement: Sb and its compounds, As and its compounds, Pb and its compounds Cr and its compounds, Co and its compounds, Cu and its compounds, Mn and its compounds, Ni and its compounds, V and its compounds Sn and its compounds
$5 (1) Nr. 3 c)*	according to the 17. BImSchV (German WID law), accumulative measurement: As and its compounds; Benzo(A)pyrene, Cd and its compounds; Co and its compounds; Cr and its compounds