

Appendix 3.3

WRATE Results



Waste and Resource Assessment Tool for the Environment (WRATE) Modelling for the Staffordshire Waste Management Options

The Waste and Resource Assessment Tool for the Environment (WRATE) is deemed to be the most appropriate tool for undertaking a study to provide a comparison of the six potential scenarios outlined in the Options Appraisal Report, July 2007.

WRATE is the Environment Agency's (EAs) approved tool for evaluating the environmental aspects of waste management activities over one year taking into account their impact during their whole life. It allows users to identify the environmental impacts from kerbside collection, recycling processes, and advanced waste treatment technologies through to ultimate reprocessing/disposal in terms of a number of environmental parameters

The scenarios are compared in terms of their contribution to global warming potential over 100 years (GWP 100) in kilograms of Carbon Dioxide (CO₂) equivalent and resource depletion in terms of kilograms of antimony equivalent. Results are expressed as 'equivalents' to take into account the potency of different parameters so they can be expressed as a common unit. For example, methane is thought to have a global warming effect 23 times that of CO₂ during a 100 year timeframe, methane can therefore be written in terms of CO₂ equivalents, i.e. 23 CO₂ equivalents. The same principle is applied to resource depletion but it is the amount of the element antimony that would need to be used to have the same impact.

It should be noted that for clarity, only the project specific disposal/ treatment options are included in this study with an offset of 55% recycling for Staffordshire's waste. The total waste arisings is 693,070 tonnes of MSW as predicted in the Options Assessment for the target year of 2020. The project specific Waste Flow and Cost Model was used to ensure that the tonnage of residual waste and recycling was comparable within the WRATE model. Therefore 381,188 tonnes are recycled (55%), 180,000 tonnes are set to the Hanford Energy from Waste plant in Stoke, leaving 131,882 tonnes to be sent to the different treatment options in each scenario.

It is assumed that the waste is delivered direct to the recycling market and residual waste treatment facility therefore the impact of transport is not taken into account. Thus the assessment focuses entirely on comparison of the alternative treatment options rather than including any complexities associated with site location. Due to the assumptions outlined in this section, the results of this study should not be deemed to provide 'absolute' but rather a comparison of the carbon footprint and resource depletion of the alternative treatment options.

In order to ensure modelling consistency, whole sections of the model upstream of the treatment/disposal route remain the same while treatment/disposal sections are changed to reflect each scenario.

Scenarios

The scenarios are based on those outlined in the Options Assessment report produced by SLR in July 2007. It has been assumed that the RDF from the MBT plant and the flock from the autoclave would be sent to an EfW plant. Due to uncertainties in the markets for the product from autoclave an additional scenario has been included with the flock being sent to fiberboard manufacture as well as for EfW. For each of the scenarios 180,000 tonnes per annum (tpa) continue to be sent to Hanford Energy from Waste plant in Stoke, this is assumed to be a power only plant (modelled on Chineham) (i.e. there is no Combine Heat and Power (CHP) element), with any ferrous material and the bottom ash being sent for recycling and the air pollution control residue being sent to landfill. A recycling rate of 55% was proposed in the report, the results for each scenario are shown both with and without the impact of recycling.

Scenario 1 – Landfill

- 180,000 tpa sent to Hanford, 55% recycling and the remaining residual waste sent direct to landfill

Scenario 2 – Energy from Waste (EfW) with Power only

- 180,000 tpa sent to Hanford, 55% recycling and the remaining residual waste sent to EFW with power only (based on the Billingham EfW plant). Ferrous material and bottom ash are recycled and the air pollution control residue is sent to landfill.

Scenario 3 – Mechanical Biological Treatment (MBT) producing Refuse derived fuel (RDF)

- 180,000 tpa sent to Hanford, 55% recycling and the remaining residual waste sent to a generic MBT plant producing RDF, the fuel is sent to an EfW with power only and the rejects are sent to landfill

Scenario 4 – MBT with bio-stabilised waste sent to landfill

- 180,000 tpa sent to Hanford, 55% recycling and the remaining residual waste sent to a generic MBT plant producing a bio-stabilised output then is sent to landfill and ferrous/ non ferrous material recycled.

Scenario 5 - MBT with Anaerobic Digestion (AD) producing Biogas and stabilite to landfill

- 180,000 tpa sent to Hanford, 55% recycling and the remaining residual waste sent to a generic MBT plant with anaerobic treatment producing biogas and compost for landfill, ferrous and non ferrous material are recycled.

Scenario 6 - Autoclave for Fibreboard

- 180,000 tpa sent to Hanford, 55% recycling and the remaining residual waste sent to autoclaving Mechanical Heat Treatment (MHT) plant, the fibre output from the process is likely to be fibre recycled to Fibreboard. Ferrous and non ferrous metal are recycled and rejects sent to landfill. It should be noted that markets for this product are highly uncertain at present.
- Due to the uncertainty of available markets for autoclave products this scenario is rerun with 50% of the flock/ recyclate captured being used and 50% being sent to landfill. This approach is recommended by WRATE

Scenario 7 - Autoclave fibre to EfW with power only.

- 180,000 tpa sent to Hanford, 55% recycling and the remaining residual waste sent to autoclaving Mechanical Heat Treatment (MHT) plant, this process includes pre-drying necessary for the fibre to be burnt in a power only EfW plant. It should be noted that there is considerable uncertainty concerning the market for the fibre from this process.
- Due to the uncertainty of available markets for autoclave products this scenario is rerun with 50% of the flock/ recyclate captured being used and 50% being sent to landfill. This approach is recommended by WRATE

Results

The aim of the modelling was to assess the environmental aspects and potential generic impacts associated with each scenario. The model can report against a range of criteria but for the purposes

of this study, Global Warming Potential over 100 years (GWP100) and Resource Depletion were the priorities.

The results produced in WRATE can feel somewhat counter-intuitive initially in that negative and low values are preferred results. This is due to the way the inventory of inputs and outputs is calculated.

WRATE calculates two types of environmental burdens:

- Burdens that occur as a result of the operation of the waste management system (inputs and outputs that are represented by positive values);
- Avoided burdens (offsets) that occur when materials and energy are recovered from the waste (i.e. recycled materials replacing virgin materials, recovered energy replacing mains electricity). These are represented by negative values.

This means that an overall negative number is possible when burdens and avoided burdens for waste management operations are aggregated. The results produced are often negative values (this because the burdens associated with manufacturing the components that make up the waste are not included in the tool). Where different scenarios are compared, lower (or more negative) numbers mean that the environmental burden of the system is smaller than the alternative.

Table 1 below shows the Global Warming Potential over 100 years (GWP100) for the total project waste for the 7 scenarios. For global warming assessments WRATE considers all the gases which contribute then multiplies them by factors equivalent to how potent they are compared with carbon dioxide over 100 years. The global warming impact is then expressed as a total weight (tonnage) of carbon dioxide. A substance's Global Warming Potential depends on the timespan over which the potential is calculated. A gas which is quickly removed from the atmosphere may, when considered in the short term, have a large effect but when considered over longer time periods the contribution becomes relatively less.

These emissions are then offset against the benefits from recycling, electricity and heat production.

Table 1: Global Warming Potential over 100 years in kilograms of CO₂ equivalent for the total project waste.

kg CO ₂ eq.	1. Landfill	2. EfW with power only	3. MBT with RDF	4. MBT with bio stabilisation
Total	-99,956,791 (6)	-127,296,374 (3)	-122,497,971 (4)	-92,140,592 (7)
Recycling	-144,060,547	-151,681,047	-148,948,681	-153,045,530
Treatment and Recovery	16,333,890	24,345,861	23,765,011	24,984,219
Landfill	27,769,866	38,812	2,685,699	35,920,719

kg CO ₂ eq.	5. MBT with AD for Biogas	6. Autoclave for Fibreboard	6a. Autoclave for Fibreboard 50% usage	7. Autoclave fibre to EfW with power	7a. Autoclave Flock to EfW 50% usage
Total	-109,000,928 (5)	-139,766,525 (1)	-118,945,685	-131,877,246 (2)	-116,140,967
Recycling	-153,045,530	-167,935,521	-155,998,034	-166,257,005	-153,685,682
Treatment and Recovery	9,223,353	27,656,485	27,656,485	33,860,916	28,196,704
Landfill	34,821,249	512,511	9,395,864	518,843	9,348,011

Ranking shown in brackets

As set out in table 1 above it can be seen that:

- The autoclave options give the largest offset of CO₂ eq, and would therefore be considered the best option from a global warming perspective. This is due to additional recycling and the offset from not having to burn fossil fuels in the EfW plant.
- A separate scenario, that has not been reported in full, was run with the autoclave flock being sent to a cement kilns, this produced a larger offset of -146,978,270 kg CO₂ eq.. Cement kilns are shown to perform well in comparison with options that are used to generate electricity because it is assumed that kilns burn only fossil fuels where electricity is generated from renewable sources and nuclear.
- Flock from autoclaves achieves a large offset because it doesn't contain any plastics, it is made up of only carbon neutral organic material, the energy from this replaces tradition fossil fuels. The plastics that are removed increase the offset from recycling. The energy produced from RDF and mass burn in EfW plants will contain plastics and therefore the offset is not as great.

It should be noted that the data used to model the autoclave process in WRATE is based on small scale plants built for demonstration purposes and markets for autoclave fibre are uncertain at the time of writing. Due to this uncertainty with respect to the availability of markets for autoclave WRATE recommends sending only 50% of product to market and 50% to landfill. It can be seen from scenarios 6a and 7a that this greatly reduces the offset from the autoclave options and shows both EfW and MBT with RDF to out perform both autoclave options.

- EfW is ranked third, giving an offset of -127,296,374 kg CO₂ eq., it out performs the remaining options due to the recycling of metal and incineration bottom ash as a reduction in the impact of landfill.
- EfW is ranked first when an allowance is made for the uncertainty of markets for autoclave products.
- It should be noted that there is only a 9% difference between the autoclave and EfW options.
- When considering the treatment and recovery plants in isolation anaerobic digestion is shown the produce the least kg CO₂ eq but due to the amount landfilled and the reduced recycling it performs badly overall.

Table 2 below shows the impact on resource depletion of each of the scenarios, this is the amount of resources consumed by the process and avoided burdens (offsets), for example, recycling and the replacement of fossil fuels in electricity generation. The results are reported as Kg antimony equivalents, which represent a common unit that takes into account the potency of different parameters much the same way as kg CO₂ eq are used as a measure of global warming potential.

Table 2: Resource Depletion as kilograms of antimony equivalent.

kg antimony eq.	1. Landfill	2. EfW with power only	3. MBT with RDF	4. MBT with bio stabilisation
Total	-1,739,638 (7)	-2,029,528 (1)	-1,962,132 (2)	-1,762,380 (6)
Recycling	-1,176,235	-1,218,631	-1,203,429	-1,229,741
Treatment and Recovery	-459,476	-811,683	-749,719	-393,432
Landfill	-103,927	785	-8,984	-139,207

Kg antimony eq.	5. MBT with AD for Biogas	6. Autoclave for Fibreboard	6a. Autoclave for Fibreboard 50% usage	7. Autoclave fibre to EfW	7a. Autoclave Flock to EfW 50% usage
Total	-1,879,119 (4)	-1,849,959 (5)	-1,726,620	-1,906,573 (3)	-1,949,260
Recycling	-1,229,741	-1,487,514	-1,331,875	-1,471,586	-1,315,715

Treatment and Recovery	-514,419	-362,283	-362,283	-434,953	-600,115
Landfill	-134,959	-162	-32,463	-34	-33,431

Ranking shown in brackets

Table 2 above shows that:

- EfW is shown to be the best option in relation to resource depletion with an avoided burden (offset) of -2,029,528 Kg antimony eq. This is due to high level of recycling and replacing electricity production from fossil fuel power stations, particularly coal.
- There is however only a 6% difference between the first three options and a 14% difference between all the scenarios modelled.
- The large offset of consumption of antimony equivalents is due in the most part to the 55% recycling rate that is proposed.

In Tables 1 and 2 the impact of the proposed 55% recycling are taking into account but in table 3 below, the impact of this recycling is not included. The table shows each scenario that are described above with the same tonnage being sent to the treatment/ recovery facilities but no offset from the 'front end' recycling. Any offsets in the table below are achieved by energy production or recycling achieved at the facility, for example, materials from the autoclave process or metals and bottom ash from the EfW plants.

Table 3: Impact of treatment and recovery option only.

	1. Landfill	2. EfW with power only	3. MBT with RDF	4. MBT with bio stabilisation
Global Warming Potential (kg CO ₂ eq.)	28,291,057 (6)	725,923 (3)	5,613,521 (4)	36,936,855 (7)
Abiotic resource depletion (kg antimony eq.)	-644,739 (7)	-935,638 (1)	-868,723 (2)	-662,164 (6)

	5. MBT with AD for Biogas	6. Autoclave for Fibreboard	6a. Autoclave for Fibreboard 50% usage	7. Autoclave fibre to EfW	7a. Autoclave Flock to EfW 50% usage
Global Warming Potential (kg CO ₂ eq.)	19,976,587 (5)	-10,720,265 (1)	9,698,864	-2,872,731 (2)	12,447,970
Abiotic resource depletion (kg antimony eq.)	-779,572 (4)	-750,417 (5)	-629,135	-807,569 (3)	-853,208

Ranking shown in brackets

Table 3 above shows that:

- The autoclave options are the only scenarios to show an offset of CO₂ eq and could therefore be considered the best option. This is partly due to the increased recycling of glass and plastics that are achieved by the autoclave process modelled in WRATE.
- However as mentioned above it is important to note that the end markets for autoclave floc are uncertain at this time and the autoclave process modeled within WRATE is based on small scale demonstration plants only. If only 50% of the autoclave product is assumed to find a market both autoclave options are out performed by EfW and the MBT with RDF.
- Sending waste direct to landfill (other than the 180,000 tonnes to Hanford) is shown to be a poor options from both a global warming and resource depletion perspective.