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Sustainability Appraisal and Life Cycle Analysis of Strategic Waste Management Options

Summary report for the South East Wales Regional Waste Group

ea/br/bl/std/vr10thanni

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Background

This report summarises work completed by Environment Agency Wales (EAW) as part of the requirement to review the South East Wales Regional Waste Plan (RWP).

The RWP was first published in 2003/4 in accordance with the requirements of Technical Advice Note 21[1] (TAN 21). Six strategic waste management options were appraised using a set of 22 indicators to determine a preferred waste management method for the plan. In these assessments, completed by SLR consulting and Applied Environmental Research Centre Ltd, the preferred option was determined to be a "Mechanical and Biological Treatment led strategy" whereby any remaining residual waste following recycling and composting of source separated materials, is treated using Mechanical and Biological Treatment facilities.

The Welsh Assembly Government appointed EAW to revisit this assessment and complete a life cycle analysis and sustainability appraisal to determine the Best Practicable Environmental Option (BPEO) and Sustainable Waste Management Option (SWMO)[2] as part of the upcoming review of the SE Wales RWP.

Methods

Before the appraisal began, 19 waste management options (detailed in figure 1) were developed and agreed at the Regional Waste Group (RWG) member level. It was decided that all options should include the same high levels of recycling and composting (for municipal waste this is over 50% of the expected waste arising). The principal differences between the options are due to the selected waste treatment technology used to manage the **residual** waste.

The options incorporate a range of waste treatment technologies including new and emerging facilities such as mechanical and biological treatment (MBT), pyrolysis, gasification as well as more established methods such as incineration with energy recovery.

RWG members reviewed the original 22 indicators used in the creation of the RWP and it was agreed that the indicators were still appropriate for the review. The suite of indicators is shown in figure 2. The sustainability appraisal provides a quantitative or qualitative assessment of each indicator for the agreed waste management options, enabling comparison of the overall performance of each option. The RWG also agreed revised forecasts for the expected arising of municipal, industrial, commercial, agricultural and construction and demolition waste streams for South East Wales in 2013.

The indicators were derived using three different methods. Eight of the environmental indicators were generated using the Environment Agency's WRATE[3] software. WRATE is a life cycle analysis tool designed to evaluate the environmental impacts and benefits of waste management systems. It supersedes the previous life cycle tool WISARD as it incorporates a greater range of waste management technologies that could not previously have been assessed. **The appraisal is the first ever project to be delivered using WRATE.**

A panel of waste management professionals considered a number of the other criteria. These were the more qualitative environmental and social indicators. The remaining indicators were created using generic data based on a range of published sources as well as data specific to the project derived from modelling assumptions (such as the assumed recycling rates). The calculation method for each indicator is also indicated in figure 2.

[1] Planning Policy Wales Technical Advice Note 21: Waste, WAG (2001)
[2] Using methods from "Strategic Planning for Sustainable Waste Management: Guidance on Option Development and Appraisal", ODPM 2002
[3] Waste and Resources Assessment Tool for the Environment, Environment Agency (2007)

Figure 1 Waste management options considered in the Sustainability Appraisal

Option 0
'Do Nothing' strategy
(This option is included for assessment purposes only – as a baseline to compare the other Options against). The same front-end levels of recycling and composting as the other options with no further treatment and all residual waste sent to landfill.

Option 1
A landfill-led strategy for residual waste
High recycling and composting levels followed by *low* levels of thermal treatment of residual waste using either:

- Pyrolysis (Option 1A), or
- Gasification (Option 1B), or
- Incineration with energy recovery (Option 1C)

All remaining residual waste would then be sent to landfill.

Option 2
An Energy from Waste-led strategy for residual waste
High recycling and composting levels with all remaining residual wastes, where possible, being treated by *high* levels of thermal treatment using either:

- Pyrolysis (Option 2A), or
- Gasification (Option 2B), or
- Incineration with energy recovery (Option 2C)
- Anaerobic digestion (Option 2D)

Any remaining residual waste would then be sent to landfill.

Option 3
An MBT/BMT-led strategy for residual waste
High recycling and composting levels, all remaining residual wastes being sent to MBT/BMT with the output recovered / disposed of using either:

- Pyrolysis (Option 3A), or
- Gasification (Option 3B), or
- Incineration with energy recovery (Option 3C), or
- Fuel to off-site energy use (Option 3D), or
- On-site Anaerobic digestion (Option 3E), or
- Landfill (Option 3F)

For Options 3A–3E, any remaining residual waste would then be sent to landfill.

Option 4
An autoclave-led strategy for residual waste
High recycling and composting levels, all remaining residual wastes being sent to autoclave with the output recovered / disposed of using either:

- Pyrolysis (Option 4A), or
- Gasification (Option 4B), or
- Incineration with energy recovery (Option 4C), or
- Fuel to off-site energy use (Option 4D), or
- Landfill (Option 4E)

For Options 4C to 4D, any remaining residual waste would then sent to landfill.

N.B. It was not possible to assess options 4A and 4B following guidance from the Environment agency's LCA Advisor that the fibre produced would be unsuitable for use for advanced thermal treatment (pyrolysis/gasification).

Figure 2 Sustainability Appraisal Objectives and Indicators

Sustainability Objective	Sustainability Indicator	Method of Measurement	Weighting
Environmental & Health Objectives			
1. To ensure prudent use of land and other resources	1(i) Depletion of abiotic resources 1(ii) Land take	WRATE output Generic Data	0.84 0.77
2. To reduce greenhouse gas emissions	2(i) Greenhouse gases emitted	WRATE output	1.27
3. To minimise adverse impacts on air quality and public health	3(i) Emissions which are injurious to public health 3(ii) Emissions contributing to air acidification 3(iii) Emissions contributing to depletion of the ozone layer 3(iv) Extent of odour problems 3(v) Extent of dust problems 3(vi) Dioxin emissions	WRATE output WRATE output WRATE output Professional Judgement Professional Judgement WRATE output	1.63 0.79 0.84 0.79 0.79 0.68
4. To conserve landscapes and townscapes	4(i) Extent of visual and landscape impacts	Professional Judgement	0.89
5. To protect local amenity	5(i) Extent of noise, litter and vermin problems	Professional Judgement	0.92
6. To minimise adverse effects on water quality	6(i) Emissions contributing to eutrophication 6(ii) Extent of water pollution	WRATE output WRATE output	0.62 1.00
Socio-Economic Objectives			
7. To minimise local transport impacts	7(i) Total waste kilometres 7(ii) Transport along roads other than motorways	Generic Data Generic Data	1.09 0.56
8. To provide employment opportunities	8(i) Number of jobs likely to be created	Generic Data	0.74
9. To provide opportunities for public involvement and education	9(i) Extent of opportunities for public involvement and education (concerning sustainable waste management practices)	Professional Judgement	0.73
Waste Management Service Delivery Objectives			
10. To minimise costs of waste management	10(i). Costs of management and disposal, including material and energy revenues	Generic Data	1.60
11. To ensure reliability of delivery	11(i) Likelihood of implementation within required timescale, taking account of maturity of technology, necessary level of public participation, and the need for planning permission (taking account of scale of development and likely perceived adverse impacts)	Professional Judgement	1.62
Public Framework Objectives			
12. To conform with waste policy	12(i) Percentage composted 12(ii) Percentage recycled 12(iii) Percentage landfilled	Generic Data Generic Data Generic Data	1.19 1.32 1.32

To enable the indicators to be combined and an overall score determined, it was necessary to put each indicator score onto a common scale. The indicators in their raw format had a range of different units. The indicators were 'valued' by assigning the best performing option for a given indicator a value of 1 and the worst performing a value of 0, the options in between were then assigned a valued score between 0 and 1 relative to each other. Following the valuing process, the 22 indicators can then be summed producing a valued score for each option.

The valued option score assumes that each indicator is carries equal importance. However, it is accepted that decision-makers are likely to attach more importance to some indicators or criteria than to others. By eliciting and applying 'weights' to the valued performance information, the relative importance of indicators has been taken into account.

Waste stakeholders including local authorities, government agencies and waste trade associations of the RWG were given an opportunity to provide their weighting of the indicators to capture a range of opinions and perspectives. Each organisation was given 22 points to divide between the 22 indicators, according to their perceived relative importance. The weightings agreed for each indicator are shown in figure 2.

Results

By following the methods above, a valued and weighted score taking account of all 22 indicators has been calculated for each option. The results of this are presented in figure 3 in ranked order (a higher score is preferable)

Figure 3 Valued and weighted sustainability appraisal scores for South East Wales

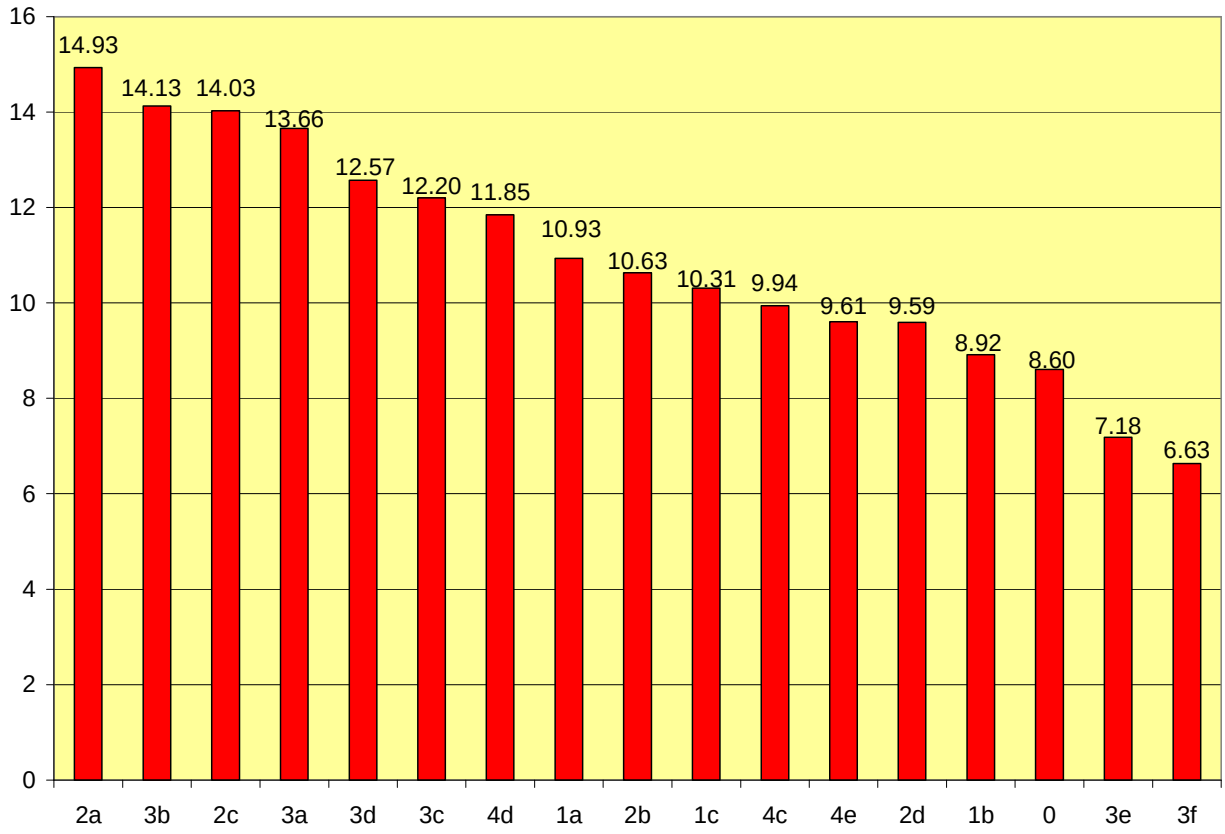

Figure 4 Overall ranking of options for South East Wales

Ranking	BPEO Indicators Valued Ranking	BPEO Indicators Weighted Ranking	SWMO Indicators Valued Ranking	SWMO Indicators Weighted Ranking
1	2a	2a	2a	2a
2	3b	3b	3b	3b
3	3a	3a	3a	2c
4	3d	2c	2c	3a
5	2c	3d	3d	3d
6	3c	3c	3c	3c
7	4d	4d	4d	4d
8	2d	2d	2b	1a
9	4c	1a	1a	2b
10	4e	4c	1c	1c
11	1a	4e	4c	4c
12	2b	2b	2d	4e
13	1c	1c	4e	2d
14	1b	1b	1b	1b
15	0	0	0	0
16	3e	3e	3e	3e
17	3f	3f	3f	3f

Diversion of Biodegradable Municipal Waste from Landfill

A separate modelling exercise for Municipal Solid Waste (MSW) only was conducted using the WRATE tool. The aim was to assess the amount of biodegradable waste landfilled to enable comparison with the expected 2020 BMW allowances made under the Landfill Allowances scheme. WRATE calculates the amount of biodegradable waste landfilled based on assumed biodegradability of each fraction of waste that is managed.

The indications from this exercise are that all options apart from options apart from option 0, 1b, 2b, 2d, 3e, 3f, 4e deliver 2020 targets by 2013. Options 1B and 2B required the use of a Dirty MRF to produce a Refuse Derived Fuel for gasification. The rejects from the MRF process required disposal to landfill and contributed strongly to the amount of biodegradable waste landfilled. A number of MRF facilities from the model were tried and in each case the landfill allowance target was breached.

Options 2D and 3E are both MBT processes, which include Anaerobic Digestion. In option 2D, the process was based on a technology that operates from Australia where the regulatory regime allows the outputs from MBT to be applied to land as a soil improver. Environment Agency guidance restricts the usage of composts derived from mixed waste and so the low-grade compost produced was modelled to landfill. A similar process operated in option 3E but this was based upon generic process data held in WRATE. The configuration was such that the MBT process also produced a Refuse Derived Fuel. As this option had no thermal treatment plant to burn the RDF, this was also landfilled.

Option 3F used a generic MBT process from WRATE (composting and RDF production) and, as with option 3E, the RDF produced as part of the process had no management route other than to landfill.

Option 4E used an autoclave to produce a fibre from the organic elements. The model suggests that a market needs to be found for the fibre as by using the process as a pre-treatment to landfill would be insufficient to meet 2020 landfill targets for South East Wales in 2013.

These outcomes should be viewed with caution as a number of factors would influence whether or not an authority met it's LAS targets. A number of assumptions have been made about the composition of the waste, the types of material removed for recycling/composting and the amount of waste in the study year (a growth scenario of 3% pa was applied for Municipal Waste).

The actual reduction of biodegradability caused by a process also requires extensive monitoring and would be likely to vary depending on the input composition. The performance of the facilities in WRATE is based on actual measurement of plant performance but this will also depend on the nature of the waste inputted. To demonstrate the actual reduction in biodegradability from a waste treatment plant, Environment Agency guidance must be adhered to.

Preferred options for SWMO criteria

Whilst it is difficult to conclusively say that one option significantly out performs the others, the results for SE Wales RWG indicate that waste management systems incorporating high levels of thermal treatment, or MBT followed by thermal treatment make up the top six options. As all of these options scored well in the appraisal, and in order to provide flexibility in the waste planning process, the conclusion from this sustainability appraisal is that any of the highest scoring options could be considered when reviewing the Regional Waste Plan.

The best performing options overall are: (top 7)

- **2a - High source segregated recycling and composting levels followed by high levels Pyrolysis,**
- **3b - High source segregated recycling and composting levels with all remaining waste being treated using MBT followed by Gasification.**
- **2c - High source segregated recycling and composting levels followed by high levels of Incineration with energy recovery**
- **3a - High source segregated recycling and composting levels with all remaining waste being treated using MBT followed by Pyrolysis.**

- 3d - High source segregated recycling and composting levels with all remaining waste being treated using MBT followed by Fuel to off-site energy use
- 3c - High source segregated recycling and composting levels with all remaining waste being treated using MBT followed by Incineration.
- 4d - High source segregated recycling and composting levels with all remaining waste being treated using an autoclave followed by fuel to offsite energy use.

It is worth noting that the difference in scores for the options are very close in some cases meaning that the order of ranking is not a fixed hierarchy of options.

Notes:

Pyrolysis treatment scores well for South East Wales. This may be due to the technology plant used in WRATE. Efficiency and emissions standards in Germany are higher than in some other European countries so its overall performance may be better than other technologies based in UK. For example, the Coventry and Grimsby incinerators may have never breached any emissions standards, but if those standards are lower than Germany's then the performance may be quite different. Pyrolysis and gasification plants do not have an established history of treating municipal waste in the UK, neither does RDF to off site energy sites such as cement kilns. Therefore, options 2c and 3c may look like more attractive and more deliverable options in this regard.

3D & 4D - It is perhaps not surprising that options that include a facility that is already in existence should score well. From an environmental perspective, the burdens are much less than for building a new facility, visual and landscape indicators score well as the facility is already in existence and the burning of the waste directly offsets the burning of fossil fuels in the cement kiln. This differs from the benefits of burning waste in an energy from waste plant as this offsets the marginal mix of power generation options assumed for Wales in 2013.

Caution must be exercised in relation to this technology choice, as the likely constraint in the delivery of these options is the availability of capacity. The model indicates a required capacity of over 400,000 tonnes per annum for 3C and over 160 000 tonnes per annum for 4D and it may be difficult to secure this capacity either within the region or further afield. There is also uncertainty as to whether any of these plants would accept the fuel due to its composition derived from mixed residual waste.

The characterisation of options and the subsequent options assessment is based on assumed generic facility capacities. Some discrimination between the size of facility appropriate to rural and urban areas has been built into the report. However, in reality, facilities are unlikely to conform to these assumed sizes, actual built capacities will depend very much on local demographic factors. The impact of facility size on the performance of options does not form part of this assessment but it is likely that larger facilities would perform slightly better than smaller facilities in overall terms. Whilst this may be the case, it does not eliminate the need for the appropriate use of smaller community based facilities which often form a fundamental part of an integrated strategy for waste management.

Whilst it is difficult to conclusively say that one option significantly out performs the others, all of the top 6 options fall under either option 2 or 3. Therefore, this study shows that Option 2: (An Energy from Waste-led strategy for residual waste) and Option 3: (An MBT/BMT-led strategy for residual waste) are in general the best-suited options overall for South East Wales. However, 2b, 2d, 3e and 3f do not perform well due to their specific nature. Options 0, 1 and 4 do not perform particularly well for South East Wales.

The conclusion from this sustainability assessment is that the highest scoring options should form a technical basis for development of the Regional Waste Plan for South East Wales.

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