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Sustainability Appraisal and Life Cycle Analysis of Strategic Waste Management Options

Summary report for the North Wales Regional Waste Group

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Background

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

The RWP was first published in 2003/4 in accordance with the requirements of Technical Advice Note 21¹ (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 this assessment, completed by SLR Consulting, the highest scoring option was a “Mechanical and Biological Treatment (MBT) led strategy” whereby any remaining residual waste following recycling and composting of source separated materials, is treated using Mechanical and Biological Treatment facilities. It was assumed that the amount of waste landfilled would be reduced such that the 2020 Landfill Directive targets would be met in 2013, and that all other relevant waste strategy targets would also be met. The option finally incorporated into the North Wales RWP was a hybrid option combining both MBT and energy from waste 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 North Wales RWP.

Methods

Before the appraisal began, 19 waste management options (detailed in figure 1) were developed and agreed at the Regional Waste Planning Group (RWPG) local authority 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 and autoclave/MHT as well as more established methods such as incineration with energy recovery.

RWG local authority 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 RWPG also agreed revised forecasts for the expected arising of municipal, industrial, commercial, agricultural, construction and demolition, and hazardous waste streams for North Wales in 2013.

The indicators were derived using three different methods. Eight of the environmental indicators were generated using the Environment Agency’s WRATE³ 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 of the RWPs is the first 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 method used to score each indicator is also documented 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/MHT-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, and weightings for North Wales

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	WRATE output	1.08
	1(ii) Land take	Generic Data	0.47
2. To reduce greenhouse gas emissions	2(i) Greenhouse gases emitted	WRATE output	2.10
3. To minimise adverse impacts on air quality and public health	3(i) Emissions which are injurious to public health	WRATE output	1.15
	3(ii) Emissions contributing to air acidification	WRATE output	0.57
	3(iii) Emissions contributing to depletion of the ozone layer	WRATE output	0.75
	3(iv) Extent of odour problems	Professional Judgement	0.36
	3(v) Extent of dust problems	Professional Judgement	0.31
	3(vi) Dioxin emissions	WRATE output	0.51
4. To conserve landscapes and townscapes	4(i) Extent of visual and landscape impacts	Professional Judgement	1.49
5. To protect local amenity	5(i) Extent of noise, litter and vermin problems	Professional Judgement	0.58
6. To minimise adverse effects on water quality	6(i) Emissions contributing to eutrophication	WRATE output	0.85
	6(ii) Extent of water pollution	WRATE output	1.32
Socio-Economic Objectives			
7. To minimise local transport impacts	7(i) Total waste kilometres	Generic Data	0.87
	7(ii) Transport along roads other than motorways	Generic Data	0.45
8. To provide employment opportunities	8(i) Number of jobs likely to be created	Generic Data	0.98
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	0.93
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	1.05
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	1.25
Public Framework Objectives			
12. To conform with waste policy	12(i) Percentage composted	Generic Data	1.48
	12(ii) Percentage recycled	Generic Data	1.77
	12(iii) Percentage landfilled	Generic Data	1.69

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 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 score, the relative importance of indicators can be taken into account.

Waste stakeholders including local authorities, government agencies and waste trade associations 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 by the RWPG for each indicator are shown in figure 2.

Results

By following the methods above, a valued and weighted score is arrived at for BPEO and SWMO. Figure 3 shows these results, both for Valued Rankings (the ranking before the weightings are applied) and the Weighted Ranking (the ranking of options after the application of the weightings).

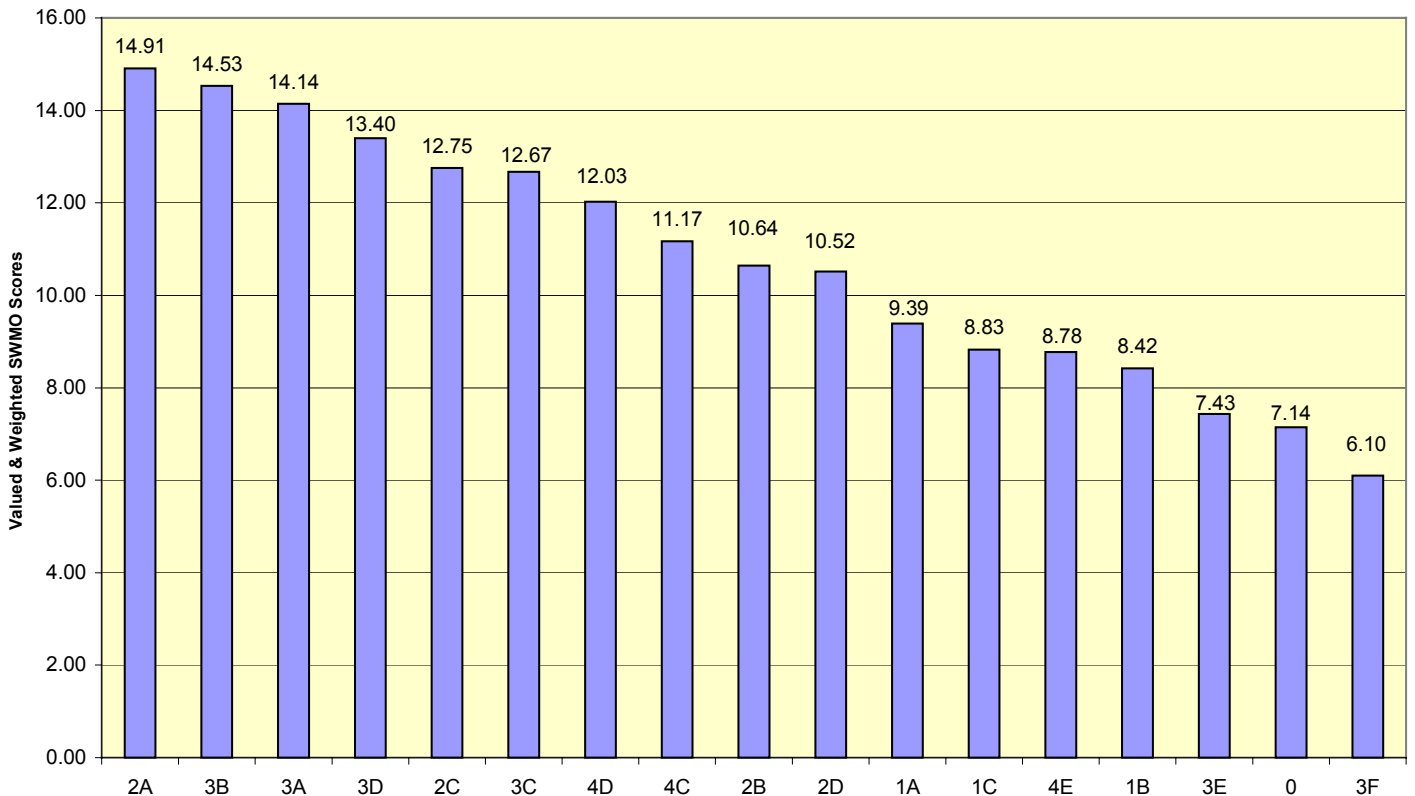
Figure 3 Overall ranking of options for North Wales

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

The ranking of the options for SWMO and BPEO are not the same. This reflects the fact that BPEO assessment is designed to concentrate on the environmental and practicability criteria, and therefore the BPEO results are the summed scores for only 16 of the 22 indicators. The socio-economic indicators are not included in BPEO, nor are the indicators dealing with visual and landscape impacts and noise, litter and vermin. Socio-economic impacts are of great importance when developing a preferred waste management option, and the SWMO scores are used for a full sustainability appraisal as they include all of the indicators.

It should be noted, however, that the same options appear in the top seven rankings both for weighted and unweighted BPEO and SWMO scores.

Figure 4 Valued and weighted sustainability appraisal scores for North Wales



Generally, the better performing options come either from the option 2 grouping or option 3, indicating that the broad strategy of thermally treating the residual waste with energy recovery, either directly or using a Mechanical and Biological pre-treatment, performed consistently well. Options from these groupings make up the top six performing options. Also performing well is option 4D, where all residual waste is treated in an autoclave/MHT with the production of a feedstock for use off-site (for instance in a cement kiln).

There are a number of exceptions to this rule. Option 2B did not score as well due to the high amount of reject from the dirty MRF process that is required to produce RDF prior to gasification. Options 2D, 3E and 3F are all MBT processes with no thermal treatment and do not perform well due to the fact that the waste is treated extensively but nonetheless much is eventually landfilled.

Option 0 was included for comparison purposes and does not score well. This reflects the situation whereby all residual waste is landfilled. As well as the poor performance scores for the sustainability appraisal, this option would not meet the requirements of the Landfill Directive to divert municipal waste from landfill.

Option 1 (do minimum thermal treatment) performs less well than option 2 (energy from waste-led strategy) indicating that it is more desirable to replace all landfill disposal with thermal treatment with energy recovery than to partially replace it.

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.

Figure 5 Conformity with Landfill Allowance Scheme targets for MSW only

Option	2020 landfill allowance met
0	No
1a	Yes
1b	No
1c	Yes
2a	Yes
2b	No
2c	Yes
2d	No
3a	Yes
3b	Yes
3c	Yes
3d	Yes
3e	No
3f	No
4c	Yes
4d	Yes
4e	No

These outcomes should be viewed with caution as a number of factors would influence whether or not an authority met its 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).

Please see the main report for further explanation.

Conclusions and recommendations

As several of the higher scoring options performed similarly, it is not possible to single out any one option as the Environment Agency's recommended strategy. However, it is important to point out some similarities between the better performing options. The best performing 6 options for SWMO criteria all fall within 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 broadly speaking the better-suited residual waste treatment options for North Wales. The option ranked 7th following weighting of the SWMO criteria was the autoclave/MHT option followed by use of the RDF in an off-site facility such as a cement kiln.

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.
-
- 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.
-
- 2c - High source segregated recycling and composting levels followed by high levels of Incineration with energy recovery.
-
- 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.

The Environment Agency's recommendation from this sustainability appraisal is that the higher performing options outlined above should form a technical basis for reviewing the Regional Waste Plan for North Wales. This allows for some flexibility in the option finally chosen, but gives broad guidelines as to the types of facilities that should be considered.

The results of these studies will be used to inform the North Wales Regional Waste Planning Group when they choose their preferred option for the Waste Plan Review but will not be used in isolation. It should be noted that a number of other studies are also to be carried out, including Health Impact Assessment and Strategic Environmental Assessment, and a full public consultation process will be undertaken before a preferred option can be incorporated into the plan.

Notes:

Pyrolysis treatment scores well for North 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 off-site energy use, as the likely constraint in the delivery of these options is the availability of capacity. The model indicates a required capacity of over 300,000 tonnes per annum for 3C and almost 130,000 tonnes per annum for 4D and it may be very 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 autoclave/MHT options 4C and 4D were modelled using a precautionary approach for the outputs. Half of the fibre and plastics is modelled as requiring landfilling, with the other 50% being sent to recycling (plastics) or on to the treatment stages. This reflects the existing uncertainty over whether secure markets can be found for these outputs.

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.

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