# Milton Keynes Council

# Best Practicable Environmental Option (BPEO) Assessment

Residual BPEO Assessment

July 2005

Entec UK Limited

# Milton Keynes Council

# Best Practicable Environmental Option (BPEO) Assessment

Residual BPEO Assessment

July 2005

Entec UK Limited

**Report for**

Andy Hudson
Chief Waste Management Engineer
Civic Offices
1 Saxon Gate East
Central Milton Keynes
MK9 3HQ

**Main Contributors**

Alison Leavens
Matthew Sellwood
Susan Marsh

**Issued by**

.................................................................
Alison Leavens

**Approved by**

.................................................................
Ken Rigby

**Entec UK Limited**

Windsor House
Gadbrook Business Centre
Gadbrook Road
Northwich
Cheshire
CW9 7TN
England
Tel: +44 (0) 1606 354800
Fax: +44 (0) 1606 354810

14939-01/MS/Report

h:\projects\wm-220\10000-14999\14939 milton keynes bpeo\d - design\mk final report05223.doc

# Executive Summary


Milton Keynes Council is currently engaged in the development and evaluation of long term options to treat and dispose of residual waste arisings. An Options Appraisal report was commissioned, in which 12 options comprising various treatment technologies were evaluated in terms of recycling, recovery cost, risk and LATS compliance. Environmental considerations were not evaluated. This BPEO assessment was commissioned to incorporate Environmental considerations into the assessment.

BPEO is a tool designed to aid Waste Management Strategy development. Its application in the planning process has however led to inconsistency and caused confusion in terms of the approaches adopted and the range of issues considered. To address this guidance on BPEO assessments was issued by the Office of the Deputy Prime Minister (ODPM). Since this project commenced, Government has published several documents for consultation which *inter alia* advocate changes to the role of BPEO assessment in both the preparation of Development Plans and the preparation of Municipal Waste Management Strategies. However, the guidance is still in draft and subject to consultation. The main consequence of the changes proposed in the various consultation draft government documents, would be that the BPEO undertaken by Milton Keynes can be used to inform the wider strategy development process and the Strategic Environmental Assessment of the Strategy which still needs to be undertaken. In the context of this project it is considered that it is still relevant and appropriate to undertake a BPEO assessment. The methodology that has been used for this study incorporates the BPEO and decision making principles set out in the consultation documents.

The derivation of assessment criteria and the subsequent weightings given to these criteria was undertaken by the Milton Keynes Waste Forum. This independent body comprised representatives from local and parish councils, local pressure groups, academic institutions and waste management companies. Two workshops were held, one to debate the appraisal indicators, the second to weight the relative importance of those indicators.

The life cycle assessment (LCA) software WISARD was used to evaluate the potential environmental impacts associated with the waste management options. MBT facilities were broken down to their constituent processes to enable these to be represented within WISARD. All other data was taken from the Options Appraisal report. Option appraisal results for each indicator were subsequently transposed into a score between 0 and 1, with 1 allocated to the option with the best performance for that criterion and 0 allocated to the option with the worst performance. All other options were given a score between 0 and 1 based on their relative performance between this established range. The weights allocated by the Forum were applied to the indicator scores, thus producing a “weighted performance score”. These weighted scores were summed allowing the options to be ranked according to their performance against the evaluation criteria and the importance with which these criteria were viewed.

Finally, as it is the intention of Milton Keynes Council to comply with their LATS targets, all options were assessed on a pass/fail basis.

The top three performing options prior to the LATS evaluation were:

| | |
|---|---|
| Option 1e | MBT, IVC (LATS compliant) and Landfill |
| Option 1c | MBT, IVC and Landfill |
| Option 2b | MT, AD and Landfill |

Options 1c and 2b fail to meet the LATS targets; leaving the top three performing options as:

| | |
|---|---|
| Option 1e | MBT, IVC (LATS compliant) and Landfill |
| Option 1d | MBT IVC and RDF sent for 3rd party combustion. |
| Option 4 | EfW |

A number of assumptions have been used in this assessment. These assumptions are necessary to enable the completion of the assessment, and an indicative ranking to be formed. However the rankings should not be taken to sanction a particular option; rather their relative positions should identify a need to the Council to evaluate some schemes in greater detail, while others can be removed from consideration.

Options 1e and 1d, both MBT IVC's score well. The two options represent different MBT technologies, Option 1e is focused on producing a LATS compliant stabalite that is either recovered or sent to landfill, while Option 1d is primarily a process that maximises the production of an RDF. Both these options will carry a different level of risk; Option 1e relies on the technology achieving the composting levels, whereas Option 1d relies on the development of 3rd party market for the RDF. If this market is not forthcoming then this option will not be realised during the procurement process. There are risks associated with the performance of both of these technologies, particularly relating to their limited track record in the UK.

Conventional combustion (direct combustion) features in four of the top five options, with the Advance Thermal Treatment (where a syngas is produced and subsequently combusted) (ATT and FBG), technology options all at the lower end of the table. Conventional combustion has fewer problems in raising project finance, as it is a well proven technology. However, it can have a negative image, often arising through mis-information or mis-understanding of the facts. This may be resolved through early and well informed consultation, including discussion forums and workshops.

It is recommended the top performing technologies (MBT and conventional combustion) are further evaluated, including open, informed discussions between Officers, Members and the public.

# Contents

# 1. Introduction

## 1.1 Project Brief

In December 2004 Milton Keynes Council commissioned Entec UK Ltd to complete a Best Practical Environmental Option (BPEO) appraisal on 11 residual treatment options. As part of this assessment Entec was required to develop environmental performance data using the Environment Agency's life cycle assessment tool WISARD. Entec was not engaged to develop the performance and economic data which was provided by Milton Keynes Council[1] .

In June 2005 Milton Keynes Council requested an additional residual treatment option to be evaluated. The performance data for this option was provided through the same source; however Milton Keynes Council sourced economic data from an alternative consultancy[2].

This report presents the BPEO evaluation of all twelve options.

## 1.2 Pre-amble

Milton Keynes Council is currently engaged in the development and evaluation of long term options to treat and dispose of residual waste arisings. As part of this process, Milton Keynes Council, in partnership with Buckinghamshire County Council engaged consultants to undertake an "Options Appraisal" to evaluate suitable treatment technologies for Municipal Solid Wastes (MSW) in the medium to long term. The results from this study were published in December 2004, and a revised report was published in February 2005.

The appraisal modelled current and potential kerbside collection schemes together and also different technical options for treating the residual wastes. The Options Appraisal study also modelled Capital and Operational costs of the different technical options, providing indicative costs for the residual treatment options at NPV in £/tonne.

It was not the objective of the Options Appraisal to include any assessment of relative environmental performance of the options. Although the appraisal presented a technical evaluation of the options, assessing performance against targets etc. it did not apply a systematic system to scoring or weighting, the relative performance of the options.

Ideally, prior to the procurement of a contract to manage and treat residual waste, a Waste Disposal Authority should first develop a waste management strategy identifying a choice of options and a process to evaluate these options. For contractors to provide solutions that have good opportunities for securing planning permissions, they require information on the type of technology that is considered to offer Best Practical Environmental Option (BPEO) in the local circumstances.

---

1 Jacobs Babtie: Buckinghamshire County Council and Milton Keynes Council, Waste Management Technical Options Appraisal Formal Issue Version 2, 8th February 2005

2 ORA, July 2005

Consequently Milton Keynes Council has commissioned Entec to complete the initial BPEO assessment with the evaluation of an additional treatment option being completed in July 2005

## 1.3 Best Practicable Environmental Option

### 1.3.1 What is BPEO

Waste Strategy 2000 places the BPEO concept at the heart of decision-making for waste management. BPEO as a concept was introduced in the 12th Report of the Royal Commission on Environmental Pollution and defined as

> *the outcome of a systematic and consultative decision-making procedure which emphasizes the protection and conservation of the environmental across land, air and water. The BPEO procedure establishes, for a given set of objective, the option that provided the most benefits or the least damage to the environment as a whole, at acceptable cost, in the long term as well as in the short term.*

The use of this tool is to provide those involved in the decision making process with a clear and rational approach to evaluating the relative merits of any set of given options. Through this approach options to manage waste can be assessed not only against their performance against to Statutory Target and Cost, but also with regard to the environmental burdens and social impacts of each option. BPEO can be applied at both strategic and more local levels.

The systematic approach has assisted in the development of waste management strategies, allowing decision makers to make value judgements of the performance of different options, by quantifying performance relative to one another, rather than measuring against an absolute value.

Although BPEO is a tool designed to aid Waste Management Strategy development, it also has uses in the planning process. However its early application to land use planning was inconsistent and caused confusion in terms of the approaches adopted and the range of issues considered. The Office of the Deputy Prime Minister (ODPM) cited this as one reason for the development of a Good Practice Guidance report. The Good Practice Guidance presents a methodology which has been used as a basis for this report. Due to the scope of this study and the timeframe required for completion some elements of the approach were modified. For example the development of strategic planning options and data collection had already been largely completed in the Options Appraisal. It was agreed with the Council that, with the exception of the WISARD modelling no new data would be modelled. In addition within the timescales there was only an opportunity for two meetings of the Waste Forum. The first was used to identify the indicators and the second to weight the importance of the indicators. This second workshop was completed prior to the completion of appraising the options and scoring. This limited the scope for debate amongst the options.

### 1.3.2 The Changing Context for BPEO

Since this project commenced, Government has published for consultation guidance documents which *inter alia* advocate changes to the role of BPEO assessment in both the preparation of Development Plans and the preparation of Municipal Waste Management Strategies. However, the guidance is still in draft and subject to consultation.

In December 2004, Defra published a document “Consultation on Changes to Waste Management Decision Making Principles in Waste Strategy 2000” (hereinafter ‘the Changes Document’). This critically reviews the role of Best Practicable Environmental Option as set out in Waste Strategy 2000. It considers the role of BPEO in the context of the spatial planning system for waste and the production of Municipal Waste Management Strategies.

At the same time Defra published ‘Consultation on Draft Guidance on Municipal Waste Management Strategies’ (hereinafter the ‘Guidance Document’ and Draft Outline Practice Guidance in support of Policy Guidance on the preparation Of Municipal Waste Management Strategies was also published for consultation in December 2004.

A consultation paper on Planning Policy Statement 10: Planning for Sustainable Waste Management was also published in December 2004 by ODPM.

The Changes Document notes that the BPEO encapsulates the following important principles:

- In taking decisions there should be consideration of alternative options in systematic way;
- Engagement with the community and key stakeholders should be an important and integral part of the decision making process;
- The environmental impact of possible options should be assessed looking at both the long and short term;
- Decisions should seek the best environmental outcome taking account of what is feasible and what is an acceptable cost.

The Changes Document goes on to state:

“These principles remain valid and need to be applied in ways that are relevant to the decision being taken.”

The Changes Document goes on to note that new and revised Regional Spatial Strategies, Development Plan Documents and Supplementary Planning Documents require a Sustainability Appraisal (which incorporates the requirements of the Strategic Environmental Assessment).

The Changes Document proposes that the process for determining BPEO in the context of the **waste management planning system** be superseded by Sustainability Appraisal and Strategic Environmental Assessment processes.

This is consistent with the revised waste planning guidance published in draft Planning Policy Statement 10 (PPS10). This does not include a BPEO objective. It states that the role of BPEO in the decision making process has been examined and acknowledges that the principles remain valid and are reflected in UK and EU legislation and its implementation. However, regional spatial strategies and waste development documents are now required to have a strategic environmental assessment (SEA) while sustainability appraisal is required by the Planning and Compulsory Purchase Act 2004. It is anticipated that the underlying BPEO principles will be achieved through a sustainability appraisal and will incorporate a consideration of socio-economic as well as environmental issues.

The Changes Document goes on to state that Strategic Environmental Assessment is a legal requirement for Municipal Waste Management Strategies and infers, although does not state in terms, that the SEA process will supersede the current decision-making process for determining BPEO.

The Changes Document and the Guidance Document put the waste hierarchy as a key objective for waste policy which should inform decision making. Where waste is produced it should be used as a resource to be put to a good use. Other key principles include the ‘proximity principle’ and the need for communities to take responsibility for their own waste.

Under the heading Decision Making Principles, the Guidance Document states:

“Waste decision-making should be based on the following principles:

- Individuals, communities and organisations should take responsibility for their waste;
- In taking decisions there should be consideration of alternative options in a systematic way;
- Engagement with the local community and key stakeholders should be an important and integral part of the decision making process;
- The environmental impacts of possible options should be assessed looking at both the long and short term;
- Decisions should seek the best environmental outcome taking account of what is feasible and what is an acceptable cost.

Authorities should apply these principles as they develop their Strategies and undertake a thorough evaluation of environmental, social and economic factors. As a minimum the Strategy will need to undergo a Strategic Environmental Assessment.”

The Change Document and the Consultation Document introduce a proposal that Waste Strategies could be integrated within the Local Development Framework and be designated a ‘Supplementary Planning Document’.

**Potential consequences of draft government guidance**

None of the foregoing invalidates the completed work which is the subject of this report. In the context of this project it is considered that it is still relevant and appropriate to undertake a BPEO assessment. At the time, the guidance set out in WS2000 and PPG10 is still relevant - and that requires a BPEO assessment to be undertaken.

The main consequence of the changes proposed in the various consultation draft government documents, if and when these changes are confirmed, would be that the BPEO undertaken by Milton Keynes can be used to inform the wider strategy development process and the Strategic Environmental Assessment of the Strategy which will need to be undertaken.

In practice, the methodology that has been used for this study, incorporates the BPEO and decision making principles set out in the consultation documents.

# 2. Methodology

## 2.1 ODPM Guidance

The Office of the Deputy Prime Minister (ODPM) has issued guidance on delivering BPEO assessments. Although principally this guidance refers to BPEO within a planning context, the basic approach is equivalent to that detailed in Waste Strategy 2000.

The ODPM noted that historically, BPEO assessments have tended to focus on environmental emissions and resource depletion, rather than on local environmental issues. The ODPM also noted that BPEO assessments commonly excluded socio-economic factors, removing the "practical" aspect from the "Best Practical Environmental Option." This presented problems in the planning system and consequently the ODPM prepared the guidance to support a wider, more pragmatic approach to the evaluation of what is the BPEO. The guidance was tested and refined through a detailed case study with the North West RTAB (Regional Technical Advisory Board), the results of which were published as the guidance document. It is this methodology that has been used as a basis for the Milton Keynes BPEO assessment.

The ODPM guidance proposed the following approach:

1. Identifying and Agreeing Appraisal Criteria;
2. Developing Strategic Waste Planning Options;
3. Data Collection;
4. Appraising Strategic Waste Planning Options;
5. Ranking and Valuing Performance;
6. Weighting Indicators.

Points 2 and 3 have largely been completed as part of the Options Appraisal. Indeed no additional data has been collated for the purpose of this assessment, with the exception of the WISARD analysis.

The Appraisal Criteria were agreed at the first Waste Forum workshop, held in December. After this workshop, the additional modeling and marking of the indicators was undertaken. For each indicator, these marks were translated into scores between 0 and 1, with 1 being the best performance, and a 0 score allocated to the worst performance. In this manner it was possible to sum the performance of an option across a range of indicators, allowing for comparison of all options. However this approach assumed that all the indicators are of equal importance. In practice though, decision makers are likely to attach a greater importance to certain criteria than to others. The relative importance of the indicators can be reflected through applying "weightings" to each performance score. The Waste Forum met again in January to assign weightings to the indicators.

Once identified, scores were multiplied by the weighting indicators to give a weighted score. The weighted scores were summed; the option having the highest score being the better performing option.

## 2.2 The Waste Forum

The ODPM guidance suggests that where possible elected members should agree objectives and indicators. However given the timescales within which this assessment is to be completed it has not been possible to consider full Member involvement in the process. Milton Keynes Council does though support a Waste Forum, which meets regularly to discuss waste issues. The Waste Forum is an informed group of individuals including representatives from Council Officers, Council Members, Parish Councilors, the Open University, the Environment Agency, pressure groups (e.g. FoE, PALs- People Against Landfills) and also from local waste management industries.

The Council proposed the Waste Forum as a platform to discuss and agree the Appraisal Criteria and also undertake the weighting exercise. The Waste Forum consented to participate in this study.

## 2.3 WISARD

WISARD (Waste: Integrated Systems Analysis for Recovery and Disposal) is a waste management software tool developed for the Environment Agency and launched in England in 1999.

The software employs a life cycle assessment (LCA) approach to forecasting the potential environmental impacts associated with the waste management options. Although the software can address potential impacts stemming from all stages in the management and processing of waste, including waste collection, transport, treatment and disposal activities, this particular assessment has focused on the treatment and disposal activities. Impacts considered include the direct emissions from management activities themselves (e.g. transport, composting, incineration, landfill etc.), those associated with the provision of infrastructure (e.g. bins, vehicles, construction of facilities etc.) and the avoided impacts associated with materials and energy recovery (e.g. offset virgin paper production or electricity generation from coal).

WISARD utilises the “avoided burden” methodology for calculating environmental burdens. This is to say it incorporates into the assessment the avoided environmental impacts of an activity or process not having to take place. For example, recycling of steel cans avoids the requirement to smelt additional iron. Thus credits are allocated to recycling activities by calculating the energy and raw materials associated with the production of that product. Credits are also assigned to those options that generate power, as this energy production is off-set against the requirement for fossil fuels (primarily coal for electricity generation). Impacts of mining activities are included in the assessment of burdens and avoided burdens.

The Entec Mass Flow Model is populated with arising and compositional data. Recyclables are removed from the “total” waste arisings based on the performance of collection and treatment systems and materials targeted. Kerbside recycling, kerbside compostable collections, bring banks and recycling from civic amenity sites are determined from the capture rates adjusted to reflect local circumstances. The model therefore provides complete compositional data for the mass of material entering any given facility.

The WISARD tool was researched during the mid-1990's and consequently only has options for those technologies prevalent at that time. These include a range of landfill options, MRF (Material Recovery Facilities) options, windrow and enclosed composting operations (although these are limited), AD operations and a range of mass burn incineration options (250-500 k tonnes per annum). The user can adapt these base options to better represent the specific technologies to be used in the model. However no options for MBT plant or Advanced Thermal Treatment plant exist.

However it is possible to "build" the constituent processes of an MBT plant from other facilities, for exampling, recycling, composting and disposal activities. Using the Entec Mass Flow Model the residual feedstock can be proportioned into five constituent processes:

1. MBT Recycle - extraction of the dry recyclable materials e.g. metals, glass;
2. MBT Compost - extraction and composting of the organic fraction;
3. MBT Moisture Loss - loss of tonnage associated with the drying process;
4. MBT RDF - extraction of the combustible fraction;
5. MBT Residue - the remainder after the above processes have been completed.

Advice has been sought within Entec on the parameters within the Incineration module that could be amended to represent Advanced Thermal Treatments. Appendix A presents an overview of the thermal treatments identified within the Options Appraisal, together with comments on how these technologies differ.

Third party combustion of the RDF is represented through a standard incinerator that complies with WID emissions. However, within the profile of this incinerator, resources required to construct and operate the facility are set to zero. The assumption is that the industrial process is pre-existing and the RDF is purely a replacement fuel, adding benefit through the displacement of fossil fuels. Thus there are no impacts associated with site construction and operation. Additionally no consideration is made of the transfer distances, principally as they are a complete unknown. However, inclusion of haulage for the RDF would partially be off-set by the haulage for the fossil fuel displaced. The energy recovery is also assumed to be power through the production of steam, rather than power through electricity generation. As the generation of steam for power is a more efficient process than electricity generation, the fossil fuel displacement will be greater, thus generating a greater net benefit than if the same fuel was used to generate electricity.

Autoclaving technologies are not represented in WISARD. In laymen's terms an autoclave is basically an industrial pressure cooker. The autoclave unit is loaded with waste and sealed. The system is pressurised with the injection of steam, this also raises the temperature. After the allotted time period the pressure is released and the unit emptied. The waste is completely sanitised, metals de-lacquered, plastics compressed and organics reduced to a fibrous material. In this form the waste is readily sorted using technology identical to that found in MBT plants. Therefore, to represent this technology in WISARD, a MRF facility was adapted to mirror the autoclave. The fuel consumption of the MRF was increased to reflect the fuel required to raise the steam and power the autoclave. However it should be recognised that the effluent associated with the condensing unit was unable to be reflected in this configuration, most notably as there is no publically available data for this. This effluent would be discharged for treatment at a sewage treatment works.

It is recognised that this type of “modulisation” is neither ideal nor totally defensible. However given the tools available and the timeframe in which the work is to be completed, this approach affords the best compromise.

# 3. Strategic Waste Management Options

## 3.1 Pre-amble

The initial eleven Strategic Waste Management Options to be evaluated were defined as part of the Options Appraisal Report. The report contains all generic and option specific data for the BPEO evaluation on the eleven options. The only additional dataset required is the WISARD output.

Subsequent to the full evaluation of the eleven strategic options, a twelfth was included. Information pertaining to the technical and economic performance data on the twelfth option was provided by Milton Keynes Council. This data originated from two sources; performance data from Jacobs Babtie and economic data from ORA Ltd.

## 3.2 Modelling

To provide the data in the format required for the WISARD analysis it was necessary to re-model the options using Entec's Mass Flow Model. This model applies the composition and waste growth profile to arisings, projecting them over a 25 year period. The model removes recyclables based on composition and capture rates, at the kerbside, through bring banks and at Community Recycling Centres (CRCs). Thus the model provides a compositional analysis of the residual waste stream requiring further treatment.

All the data required to populate this model was extracted from the Options Appraisal. Due to the difference in model construction, slight differences arise in the quantity of specific materials captured for recycling. However these differences are insignificant and the overall recycling and composting rates are the same.

## 3.3 Waste Composition and Arisings

Waste compositional and arisings data was taken from the profiles provided in the Options Appraisal.

## 3.4 Kerbside Recycling

The level of kerbside or "front end" recycling will impact the amount and composition of the residual waste to be treated. The Options Appraisal Report modelled two different rates of performance for front end recycling: planned and optimised. The "planned recycling" met all the Councils recycling and composting targets; the "optimised recycling" exceeded these targets.

The Council decided that for the purpose of this BPEO assessment, the 'Exceeds Target' scenario should be assessed. This decision dictates which data (capture rates, tonnages etc.) should be used in the BPEO assessment process. However it should be noted that the front-end recycling at the Exceeds Target level is the same for all treatment options. Thus the BPEO evaluation is effectively evaluating the difference between the residual treatment options.

## 3.5 Residual Treatment Options

Eleven residual treatment options are modelled in the Options Appraisal Report. They are:

**Table 3.1 Technology Options**

| Option | Technology Option as described In Options Appraisal Report |
|---|---|
| 1a | MBT + ATT + IVC |
| 1b | MBT + FBG +IVC |
| 1c | MBT + IVC + Lf |
| 1d | MBT + IVC +RDF (to 3rd party) |
| 1e | MBT + IVC (LATS compliant) + Lf |
| 2a | MT + ATT + AD |
| 2b | MT + AD + Lf |
| 2c | MT +AD + RDF (to 3rd party) |
| 3a | Screening and ATT |
| 4 | EFW |
| 5a | AC + ATT |
| 5b | AC + Lf |

Option 1e was added at a latter stage to represent a composting MBT plant that ensured LATS compliance for the WDA.

The technologies that have been proposed in the Options Appraisal are listed below. The abbreviations relate to those in Table 3.1.

- AC - Autoclave
- AD – Anaerobic Digestion
- ATT - Advanced Thermal Treatment
- EfW - Energy from Waste
- FBG - Fluidised Bed Gasification
- IVC - In-vessel Composting
- MBT - Mechanical Biological Treatment
- MT - Mechanical Treatment

- RDF - Refuse Derived Fuel
- Lf - Landfill

The Options Appraisal Report provides a brief narrative on each of the aforementioned technologies. However it is Entec's experience that there is confusion within the waste management industry with regard to what "Advance Thermal Treatment" is and the differences between "conventional combustion" (EfW) and these so-called Advanced Thermal Treatments. Appendix A explains the thermal treatment options, and seeks to clarify some common misconceptions.

# 4. Agreeing Evaluation Criteria

## 4.1 Pre-amble

The Waste Forum met to agree the evaluation criteria. The meeting was held at the Council Offices on the 15th December 2004. A brief presentation of BPEO assessments and the emerging SEA and SA framework was presented.

## 4.2 Workshop

### 4.2.1 Presentation of ODPM indicators

Entec presented the Waste Forum with the 21 indicators identified in the ODPM Guidance. These 21 indicators are presented in Table 4.1. Given the tight timescales to complete the BPEO assessment Entec recommended that the number of indicators be rationalised to a manageable number. Thus the purpose of the workshop was to inform members of the process being undertaken, and gain consensus on the indicators that should be taken forward for evaluation.

The scope of the commissioned BPEO assessment was to evaluate the treatment options at a WDA level for residual waste only. All 12 options have the same front end recycling and composting.

At this stage in the process there has been no identification of potential sites where waste management infrastructure may be located. For the purposes of this assessment each technology option has been assessed on the assumption that one site, the same for all options, somewhere within Milton Keynes would be developed. Members were also informed that for the evaluation of environmental criteria, all options would be assessed based on the assumption that they complied with all regulatory requirements e.g. discharge consents.

**Table 4.1 ODPM BPEO Indicators**

| Objective | Indicator |
|---|---|
| 1. To ensure prudent use of land and other resources | 1. Resource depletion |
| | 2. Landtake |
| 2. To reduce greenhouse gas emissions | 3. Emissions of greenhouse gases |
| 3. To minimise air quality impacts | 4. Emissions injurious to public health |
| | 5. Air acidification |
| | 6. Ozone depletion |
| | 7. Extent of odour problems |
| | 8. Extent of dust problems |

| Objective | Indicator |
|---|---|
| 4. To conserve landscapes and townscapes | 9. Visual and landscapes impacts |
| 5. To protect the local amenity | 10. Extent of noise problems |
| | 11. Extent of litter and vermin problems |
| 6. To minimise adverse effects on water quality | 12. Eutrophication |
| | 13. Extent of water pollution |
| 7. To minimise local transport impacts (e.g. congestion) | 14. Total transport distance |
| | 15. Proportion of total transport distance along roads other than motorway |
| 8. To provide employment opportunities | 16. Number of jobs created |
| 9. To provide opportunities for public involvement and participation | 17. Potential for participation in recycling and composting |
| 10. To minimise cost of waste management | 18. Overall costs |
| 11. To ensure reliability of delivery | 19. Likelihood of implementation within required timescales |
| 12. To conform with waste policy | 20. Percentage of material recovered |
| | 21. Percentage of material recycled/ composted |

Forum members were informed that the following indicators would be evaluated in the WISARD software:

- Resource depletion;
- Emissions of greenhouse gases;
- Emissions injurious to public health;
- Air acidification;
- Ozone depletion;
- Eutrophication.

The programme allowed for the indicators to be discussed and for members to add or remove indicators. At the end of the discussion Forum members were invited to vote for their “top 10” indicators and their “bottom 5”. Using this method the number of indicators was narrowed to a manageable number to be assessed within the timescales.

The Forum broke into two groups, with an Entec member of staff facilitating in each group. Entec provided information pertaining to each of the ODPM indicators, what was to be measured and how they would be evaluated.

The following presents a brief synopsis of the criteria as discussed.

**Resource depletion**

Resource depletion was considered to be a major consideration for the BPEO assessment. Options that encourage more recycling would mitigate against resource depletion; both in the conservation of that particular resource, but also the conservation of the inherent energy of that resource, for example, the required energy expended at all stages of manufacture. Forum members agreed that this is both a local and global indicator, with local environments being affected by natural resource depletion and this clearly having an overall impact upon the global environment.

A number of attendees expressed a concern that this indicator does not sufficiently account for the depletion of resources higher up the waste disposal process. It was commented that for every item of waste that is combusted, replacements are required. Natural resources (materials and fuel etc.) are utilised in this production process so therefore are technically being depleted by the waste disposal process. It is this depletion that a number of attendees suspected is not totally accounted for in the BPEO assessment (especially WISARD modelling).

**Landtake**

The amount of land required to build waste disposal facilities in Milton Keynes was not regarded as a major consideration. It was commented by some attendees that Milton Keynes is an area that has already attracted significant development of large ware-house types of development in the industrial and commercial zones. In this instance another similar construction may not be viewed as being out of keeping with its surroundings.

**Emissions of greenhouse gases**

Greenhouse gas emissions were discussed in a global context, as they are difficult to quantify for Milton Keynes. It was agreed that this is a high profile topic at present with leading politicians discussing the current position. The general consensus of the Forum was that this indicator relates to the level of environmental acceptability of the technologies.

**Emissions injurious to public health**

It was agreed that this indicator is one of the locally specific assessment criteria. The release of emissions injurious to public health would affect the residents of Milton Keynes in terms of their quality of life and is therefore high profile. A number of the Forum Members indicated that to remove this indicator would be against the best interests of the local people but could also be controversial in terms of the negative publicity that decision would generate.

**Air acidification**

The Forum discussed the problems associated with air acidification and concluded that this indicator was largely covered by the ‘emissions injurious to public health’ indicator. It was also mentioned that planning and licensing regulations would control this factor to a certain extent anyway.

**Ozone depletion**

It was debated by the Forum that Ozone depletion should not be a major consideration in this BPEO since the ‘emissions of greenhouse gasses’ indicator would largely include many of the gases which cause Ozone depletion. It was again argued that the planning and licensing process for such facilities would limit Ozone depleting emissions to a globally acceptable level anyway.

**Extent of odour problems**

The issue of odour problems was not considered an important indicator for use in the BPEO assessment. The Forum debated that odour problems are very localised and that modern technologies can reduce this factor to an acceptable level. The comment was made that the facilities discussed are frequently enclosed, with waste reception areas operated under negative pressure thus preventing the escape of unpleasant odours. This is a design option that is often provided to facilitate good neighbourly relations.

**Extent of dust problems**

The perception of the Forum was that problems associated with dust are again localised and the enclosed nature of most technologies limits this as a problem. It was commented that this indicator would enable little differentiation between the technologies and options through the BPEO process.

It was also commented that this indicator would be hard to assess since transport factors are being excluded at this stage. The Forum did conclude however that dust problems should constitute part of any transport assessment undertaken.

**Visual and landscapes impacts**

The visual impact of waste facilities was debated slightly more passionately by the Forum as it clearly impacts upon the local environment. Modern waste management facilities can benefit from design that is sympathetic and in keeping with its surrounds, thus minimising visual intrusion. Moreover, the Forum felt that as virtually all development around Milton Keynes comprised modern shed/warehouse type developments, it was not considered that additional modern facilities would detract greatly from the overall visual landscape.

A number of attendees did suggest that failing to assess the visual impact of facilities would be badly received by certain sections of the community, particularly those living in the vicinity of such facilities.

**Extent of noise problems**

The major concern of the Forum regarding noise pollution was associated with the noise generated by the delivery and transport of waste to and from the facilities. This will not be an aspect of the BPEO assessment and is therefore considered to be an unhelpful indicator.

It was commented that this does not mean that the Forum considers noise pollution to be unimportant in the overall scheme of the facilities, but believes that the issue better addressed through any transport assessments. It was also stated that the operator will be restricted by noise abatement clauses in the licence as well.

**Extent of litter and vermin problems**

The issue of litter spread was discussed by the Forum but was not anticipated to be a major factor in terms of assessing enclosed technologies, since almost no waste will be open to the elements. All waste management activities will have operational conditions set by licensing authorities to manage and control litter and vermin. Landfills, due to their open nature are likely to suffer from these issues to a greater extent if proper controls are not set and followed, for example covering of materials upon deposit or at the end of the day.

The aspect of litter spread which created debate (and concern) was that associated with waste being transported to and from the facilities, but again this impact should be assessed during the transport review.

Vermin control was decided to be a local issue which would be addressed through the licensing and regulatory regime. The evaluation would assume that all facilities were operating to the same standard of litter and vermin control, and therefore the assessment would not be able to distinguish between options with regard to this indicator.

**Eutrophication**

The process of Eutrophication was explained. Eutrophication is a natural process, occurring where there is an increase of mineral and organic nutrients in a water body (principally nitrogen and phosphorous). The enrichment promotes both plant growth and microbial activity which, providing an unlimited nutrient supply, eventually results in the de-oxygenation of the water body. De-oxygenation of a water body results in fish kills and an alteration to the ecology of the system. Direct Discharge many not be the only source of pollutants, with nutrients being "harvested" from the atmosphere during rain-fall.

Forum members agreed that this was an important environmental indicator.

**Extent of water pollution**

This covers wider aspects of water pollution rather than the specifics of Eutrophication, and is more focused on the impacts associated with direct discharges to water bodies.

**Total transport distance and Proportion of total transport distance along roads other than motorway**

Among the Forum it was agreed that the impact of transportation cannot be readily addressed unless potential locations have been identified (or assumptions made about locations) for additional treatment facilities, and for the onward treatment of their outputs.

Locations have, as yet, not been identified so these indicators have not been considered as part of the BPEO assessment process.

**Number of jobs created**

Unemployment is currently very low in Milton Keynes according to official figures and it was commented by the Forum that jobs in the waste industry may not be that desirable enough to encourage workers to leave their current positions. It is unlikely facilities will experience difficulty recruiting employees but it was agreed that this indicator is not important in terms of assessing the BPEO.

**Potential for participation in recycling and composting**

The BPEO assessment process referred to in the ODPM guidance includes this indicator which enables one to asses the potential for community involvement in recycling and composting. The ODPM guidance pertains to a study where the entire waste management system is reviewed, both collection and disposal. In their example different options offered varying rates to participate in recycling and composting schemes. This BPEO study has taken the Exceed Targets scenarios from the Option Appraisal report, thus there is the assumption that the Council has embarked upon a programme of campaigns to educate and encourage the public to participate in recycling and composting schemes to a level nearing the maximum. In addition it is recognised that all treatment options could include educational and viewing facilities for the general public, and in this instance there would be no manner in which to differentiate between the options. Thus, in the context of this study this indicator was deemed to be inappropriate.

**Overall costs**

The importance of the overall costs of the schemes was debated by the Forum. Some attendees stated that the cost was extremely important in terms of saving money for both companies and the Government, while other attendees suggested that the appropriate technologies should be chosen at whatever the cost.

Attendees from the Private Sector pointed out that there are not unlimited resources available in terms of funding these schemes through PFI, and that overall costs must be considered as part of the BPEO assessment process.

The wording of the indicator was debated at length too with a general consensus view that the wording should not be ‘overall costs’ but should be ‘overall costs and best value’. This enables the indicator to be read as a tool to assess how to optimise the cost of waste management rather than ‘minimise it’ as described in the ODPM guidance.

**Likelihood of implementation within required timescales**

The Forum debated that implementation within given timescales was important as an indicator since failure to achieve this would impact upon waste management performance and the finances of the schemes.

**Percentage of material recovered**

There was some debate as to whether this is an important indicator or not. There was a view that this indicator is unnecessary since all local authorities are already governed by European and UK legislation which sets recycling and recovery targets. However some attendees believed it is important for high performing technologies to be able to be awarded ‘bonus’ (or in this case a higher score) points for achieving recovery rates above those required by legislation.

**Percentage of material recycled/ composted**

See comments above, as the same principle applies.

### 4.2.2 Consensus on removal and addition of indicators

After discussions the two groups were brought together and a member from each group was invited to present their discussions. Where consensus on the removal of specific indicators had been reached these were removed. Where consensus across the group for addition of indicators was reached, these were added.

Table 4.2 presents a summary of the indicators removed and the reasoning behind their elimination.

**Table 4.2 ODPM BPEO Indicators removed through consensus**

| Indicator | Reasoning |
|---|---|
| Extent of noise problems. | Noise is an indicator that is more suitably assessed at a site level. In addition planning will require a noise assessment and possibly noise abatement measures |
| Extent of litter and vermin | This indicator was deemed inappropriate as all residual treatment options would be enclosed and assumed to comply with IPPC / WML conditions |
| Total Transport Distance | All front end transport impacts would be the same for each option. As no sites are identified it would not be possible to identify transport distances to reprocessor / landfills. This indicator should be evaluated once sites are identified. |
| Proportion of total transport distance along roads other than motorway | As above. |
| To provide employment opportunities | It was agreed that this would be a difficult indicator to evaluate, and that the data was not readily available. Also the evaluation was on residual treatment options, and did not include the front-end recycling where traditionally more jobs are employed. |

The following indicators were added:

**Reliability of technology**
This indicator was added as it was deemed imperative that any chosen technology should be able to deliver; it was suggested that there is little point basing an entire strategy upon technology which has not yet been proved to work.

**Minimise hazardous discharge to land**
The Forum decided that an additional indicator should be put forward for consideration that assessed the possibility of contamination to land. It was commented that discharge to water has been included on the list but that no account of discharge to land has been included.

**Ability to cope with change**
This indicator was added by the Forum for consideration as it relates to the technologies abilities to adapt to changing legislation, markets, materials, environmental emissions requirements etc. This is effectively an indicator which will assess the adaptability of the technologies incorporated in the schemes.

### 4.2.3 Voting for preferred indicators

Having identified, by informed debate, a list of indicators to select from, the Forum attendees were asked to vote for two sets of indicators: the 10 which they believed to be of the highest priority, and the 5 which they deemed to be of the lowest. The revised "voting" list consisted of 18 indicators.

Table 4.3 presents the results of the voting exercise.

**Table 4.3 Record of Voting at Waste Forum Workshop**

| Highest Priority | Indicator | Lowest Priority |
|---|---|---|
| ●●●●●● | 1. Resource depletion | |
| ●● | 2. Landtake | ●●● |
| ●●●●●● | 3. Emissions of greenhouse gases | |
| ●●●●● | 4. Emissions injurious to public health | |
| | 5. Air acidification | ●●● |
| | 6. Ozone depletion | ●●●● |
| ● | 7. Extent of odour problems | ●●●●● |
| | 8. Extent of dust problems | ●●● |
| ●● | 9. Visual and landscapes impacts | ●●● |
| ●●● | 10. Eutrophication | |
| ●● | 11. Extent of water pollution | ● |
| ●●●●●●● | 12. Overall costs | ● |
| ●●● | 13. Likelihood of implementation within required timescales | ● |
| ●●● | 14. Percentage of material recovered | ● |
| ● | 15. Percentage of material recycled/ composted | ● |
| ●●●●●●●● | 16. Reliability of Technology | |
| ●●●●●● | 17. Minimise hazardous discharge to land | |
| ●●●●●● | 18. Ability to cope with change | |

Ten indicators received three or more votes when voting for the "highest priority". Six indicators received three or more votes for the "least priority". It was agreed that those six, scoring three or more votes for the least priority would be removed as evaluation criteria.

### 4.2.4 The Chosen Indicators

The following list of indicators resulted from the Waste Forum's discussions and voting exercise, and will therefore be used during the BPEO assessment:

- Resource depletion;
- Emissions of greenhouse gases;
- Emissions injurious to public health;
- Eutrophication;
- Extent of water pollution;
- Overall costs & Best Value;

- Likelihood of implementation within required timescales;
- Percentage of material recovery;
- Reliability of technology;
- Minimise hazardous discharge to land;
- Ability to cope with change;

# 5. Appraisal and Scoring Indicators

## 5.1 Appraisal Methods

The indicators were appraised by one of three methods:

- Use of quantitative assessment tools (WISARD);
- Use of generic data on the performance of options;
- Use of professional judgement to assess the performance of options.

Table 5.1 presents the method by which each indicator was assessed.

**Table 5.1 Appraisal methods for each indicator**

| WISARD | Generic Data | Professional Judgement |
|---|---|---|
| Resource Depletion | Percentage of waste recovered | Extent of water pollution |
| Emission of Greenhouse Gases | Percentage of waste recycled/ composted | Likelihood of implementation within required timescales |
| Eutrophicaton | Overall cost & Best Value | Reliability of technology |
| Emissions injurious to human health | Minimise hazardous discharge to land | Ability to cope with change |

## 5.2 Appraisal Results

### 5.2.1 WISARD Assessment

**WISARD inputs & technologies**

Four indicators were assessed using the WISARD LCA tool. Data was calculated from Entec's Mass Flow Model. Using this model the composition of the residual waste stream was determined as:

| | |
|---|---|
| Paper & Card | **15%** |
| Glass | **2%** |
| Textiles | **3%** |
| Ferrous | **2%** |
| Nonferrous | **1%** |
| Plastic Film | **3%** |

| | |
|---|---|
| Dense Plastic | **3%** |
| kitchen | **16%** |
| Garden | **8%** |
| Misc Combust | **38%** |
| Misc Non-combust | **4%** |
| fines | **5%** |

It was not possible using this compositional breakdown to reflect the proportioning of the residual waste stream cited in the Option Appraisal for all Options. Specifically Options 3, 5a and 5b could not reflect their reported split. This was principally due to the Options Appraisal assigning levels of recycling that could not be matched by the Entec Mass Flow Model. For example in Option 3 the Options Appraisal Report presents a flow of: 87% RDF, 4% RDF rejects and 9% recycling (metals). However in can be seen that the residual waste stream does not contain 9% metals, only 3%. Thus the assumption made in the Options Appraisal can not be reflected in the WISARD modelling. This issue was raised with the Council and it was agreed that Entec would revise the flows to reflect the predicted residual composition. The assumed technology mass flows, together with Entec amended flows are presented in Appendix B.

The only thermal treatment option within WISARD is an Incinerator. This was adapted to reflect the different parameters of the feedstock and energy recovery. For example the proportional spilt between Total Carbon, Mineral Matter and Water is different in an RDF than in residual waste. Likewise the calorific value of the waste is different. Energy experts were consulted for values of parameters including LHV (Lower Heating Value- also known as Net Calorific Value or NCV) Electricity kWh/month (energy recovery) and gas cleaning outputs. The gas cleaning outputs were deemed the same for all technologies (on a mg/Nm$^3$), and were set to comply with the Waste Incineration Directive. Whilst it may be true that some waste incinerators breach their emissions consents, this is also true of alternative combustion processes. In addition, while some alternative technology providers may argue that their technology has far lower emission, Entec are not aware of a single advanced thermal treatment technology provider that will guarantee emissions that are below WID using an MSW feedstock. As options can only be assessed on what is bankable and guaranteed it was deemed appropriate to use the same (WID) emissions for all combustion processes (including 3$^{rd}$ party combustion of RDF).

As detailed in Section 2.3 autoclaving technologies are not represented in WISARD. In this instance autoclave units were represented by a MRF facility, with fuel consumption increased to reflect that required to raise the steam and power the autoclave. Treatment of the effluent arising from condensing the steam could not be reflected in the MRF configuration.

**Greenhouse gas emissions**

The global warming potential of a waste management system is currently dominated by the generation of methane and carbon dioxide emissions. Methane is a far more potent greenhouse gas than carbon dioxide and consequently is a significant consideration in waste management options (in general terms, landfill gas comprises between 40-65% methane). Thus the global warming potential of each scenario is linked to the methane emissions, which is dependant upon the amount of biodegradable waste disposed to landfill. The next significant source of green house gases is the combustion of waste, as this will produce carbon dioxide. If it is assumed that there is energy recovery from this combustion, then WISARD off-sets emissions that would otherwise have been incurred through the combustion of coal at coal fired power stations.

The model evaluated all emissions associated with the option, from the emissions of gases associated with the combustion of waste together with the off-set emissions of not having to combust coal for the production of additional materials (in the case of recycling) or electricity / energy (in the case of using waste as a substitute fuel). The assessment methodology used was the IPCC (Intergovernmental Panel on Climatic Change) greenhouse gas net effect -100 year method which is calculated in grams equivalent of carbon dioxide ($CO_2$).

All those options that diverted significant volumes of waste from landfill had an associated avoided burden. Options 1c, 2b and 5b, all of which landfilled significant volumes had a positive impact. As described above this is due to the significant volumes of landfill gas. Although it is assumed that the landfills will be managed to high standards, with energy recovery from landfill gas, there will always be an element of fugitive emissions, and it is these emissions that generate the positive impact. Those options with the greatest amount of recycling/recovery and the least landfilling have the best performance.

**Resource Depletion**

The world contains finite resources in terms of minerals and fossil fuels. The rate at which these resources are consumed is important when assessing the sustainability of any activity. The model evaluates the consumption of all raw materials for a particular option. Recycling of metals and plastics preserves both the mineralogical value of the item as well as its intrinsic energy content e.g. the energy consumed in production of the material. Energy from Waste facilities produce electricity and heat that is assumed would otherwise be generated from a fossil fuel, thereby conserving that resource. Recycling of a plastic bottle would preserve more resources than sending the bottle for energy recovery (as both the mineralogical and some of the intrinsic energy are recovered), but both preserve resources when compared to landfill. Thus options that can optimise recycling and energy recovery from the waste stream are the most sustainable in terms of resource use. WISARD uses the EB(R*Y) calculation method, measured in $year^{-1}$ (i.e. per year).

All the options show an “avoided resource depletion”, or a net benefit. For all options the avoided resource depletion arises from the recycling activities within the MBT plant. The more materials recycled or composted, the greater the avoided burden. In this instance anaerobic digestion performs slightly better than composting, although this difference could be attributed to the manner of the evaluation (the way in which MBT has been represented in WISARD). The best performing options in this indicator were 1d and 2c.

**Emissions injurious to public health**

Emission injurious to public health can be to all media, air; waters, and land. Human toxicity is a measure of the potential risk to health from waste treatment facilities. Those options with combustion were the poorest performers, with emissions proportional to the amount of material combusted. Those options without any form of combustion performed well, and the increased recycling from the autoclaving treatment process made this option perform best.

**Eutrophication**

Eutrophication is a natural process, occurring where there is an increase of mineral and organic nutrients in a water body (principally nitrogen and phosphorous). The enrichment promotes both plant growth and microbial activity which, providing an unlimited nutrient supply, eventually results in the de-oxygenated of the water body, De-oxygenation of a water body results in fish kills and an alteration to the ecology of the system.

As anthropogenic activities increase the nutrient loading to surface waters (through direct discharges such as sewage effluent and indirect discharges such as fertiliser run-off) so the occurrences and magnitude of this natural process escalates. Costs are not confined to the ecosystem, but arise from loss of amenity value; damage to commercial fishing, increased costs for water treatment and additional costs required to mange the systems.

Anaerobic Digestion does not perform well with regard to this indicator due to the potentially high loading to waters, with options 2a, 2b and 2c having the worst performance. The higher recycling achieved with autoclaving is responsible for Options 5a and 5b better performance.

### 5.2.2 Generic Data

The generic data was either available in the Options Appraisal report or was extrapolated from the modelling undertaken by Entec. For example the Overall Cost data was taken from the Option Appraisal report whilst the percentage recovered, percentage recycled / composted and tonnage of hazardous waste discharged to landfill was taken from the Entec Mass Flow Model (which use the Capture rates, waste growth profile and waste composition provided in the Options Appraisal report). Hazardous discharge to land was calculated as the tonnage of Air Pollution Control residue (APC residue) sent to landfill. This figure was calculated as 3% of the input tonnage for each thermal treatment plant.

The initial Options Appraisal Report provided cost estimates for all of the original 11 residual treatment options. When commissioned to complete the additional evaluation of Option 1e Jacobs Babtie did not provide cost information along with the other performance data. Consequently Milton Keynes Council commissioned ORA to provide cost data for this Option. ORA provided Milton Keynes Council with two costed options, Option 1c and 1e. Milton Keynes Council requested Entec to use the provided data to identify a ratio between the ORA and Babtie costs and apply this ratio to the ORA costs for Option 1e. The intention of this exercise is to bring the ORA Option 1e costs into line with the other Jacobs Babtie costs

### 5.2.3 Professional Judgement

Several of the indicators required professional judgement to score, specifically reliability of technology, implementation within timescales and ability to adapt to a change. Within Entec a meeting was held to discuss the options against each indicator. This meeting was attended by the most senior staff members of the waste management group, who at present are involved in some of the largest municipal waste management procurement contracts within the country. Their considerable experience in the field of waste strategy development and project procurement (including extensive experience in developing OBC's and PFI projects) means they have established contacts with all parties involved in contract procurement, including financial consultants, risk consultants, bankers and, the principal policy and decision makers at the Defra and the Treasury.

This panel of experienced waste management consultants discussed each of the options with respect to each indicator. Panel members marked each option individually against each criteria and these scores where then rationalised to a single score through discussion and debate. Appendix A provides details of thermal treatment processes, including issues pertaining to the economics and risks associated with these processes.

**Reliability**

The reliability of each option was judged against what has been proven to work at the scale demanded by the option; with the emphasis on will the technology work once built?

Conventional combustion technologies are widely applied and their performance and economic characteristics sufficiently well understood such that lenders are generally comfortable with providing finance to such projects.

The recent history of developing EfW projects based on ATTs has seen some very notable technical and commercial difficulties, such as those associated with the EDL/SWERF technology in Australia and the even more recent difficulties with the Thermoselect project in Karlsruhe. These projects underline the fact that there are very few EfW projects using ATTs that have a long-term track record of operating success.

ATTs are the subject of much development work. Many gasification and pyrolysis technologies have been successfully used on a wide range of feedstocks, but there are only a few that have operated on mixed solid wastes. Where there *are* commercial case-studies with track record, they tend to be 'heat' gasification or pyrolysis systems in which not all of the *potential* environmental or efficiency advantages of ATTs have been captured.

To date, there are no examples of any projects using ATTs in the UK that have successfully secured significant debt finance.

On this basis, on a scale of 1-10 all ATTs were judged as 1. Technologies that included an element of landfill were marked high as this method of disposal is dependable. Issues relating to LATS and costs are dealt with elsewhere. EfW also scored well, as this type of technology is tried and tested and there is considerable experience of this technology within the UK. Options with a reliance on an RDF market were scored lower than the options in which the RDF was sent to landfill as there can be no guarantee that this market will emerge.

The Environment Agency is currently developing guidance on the level of reduction in biodegradablilty of outputs from composting based MBT plants. It is likely that plants that have been designed to achieve high levels of reduction of biodegradability will provide a treatment technology that will allow the resulting output material to be landfilled at the same time achieving a sufficient level of treatment to also compliance with LATS targets. However, there are no current reference plants in the UK where the technology has been used in this mode. Consequently Option 1e has been marked down slightly on Option 1c to reflect this lack of track record.

**Bankability - Ability to implement within required timescales**

The deliverability of each option was judged against its "bankability".

Conventional combustion technologies are widely applied and their performance and economic characteristics sufficiently well understood such that lenders are generally comfortable with providing finance to such projects.

A local authority has a number of priorities in the development of waste management solutions. Compliance with the waste management hierarchy, achievement of recycling, composting and recovery goals, environmental performance, and cost are all vital. Of great importance, also, is the reliability of the technologies used as part of an integrated waste management solution. This issue of technical efficacy and reliability is of critical importance to all stakeholders in any project – it is a key risk area that any project investors will want to be effectively managed.

Even if a technology can be shown to have some operating track record on the fuel proposed for a particular project, an investor (lender or equity) is still likely to need a technology provider or project contractor to provide robust guarantees to protect revenues associated with the performance and reliability of the project. So not only is a technical track record needed, so too is a bankable guarantee from a robust commercial organisation. Banks are very unlikely to accept performance risks sitting in the project – such risks must be borne by the sponsor, the technology provider or the contractor.

There are no advanced thermal treatment EfW projects in the UK that have secured significant debt finance. This may be due largely to:

- Lack of operating experience on which to validate performance claims underpinning the project financial model;
- Lack of financial backing amongst technology suppliers to reduce lenders exposure in case of performance shortfall;
- Lack of credible turnkey project partner (although some new relationships between technology providers and turnkey contractors have formed in recent months);
- Questionable commercial viability.

Consequently, advanced thermal technologies may require extended periods of performance demonstration in order to provide the necessary assurances to secure conventional debt finance at usual gearing levels. This may be achieved through DEFRA's New Technologies Programme, but this capital grants scheme is unlikely to affect the widespread bankability of such technologies in the near term.

At present there is limited market for RDF and those options that include RDF combustion by a third party are reliant on an RDF market emerging in the future. This option therefore includes a significant risk and the viability of such an option will be dependant upon securing ownership for this risk element.

On this basis, on a scale of 1-10 the smaller scale ATTs were judged as 3, with the larger scale ATTs judged as 1. Landfill scored high as this is a proven technology within significant experience and expertise within the UK. AD is less proven and was therefore scored fewer marks than landfill. MBT & IVC are both proven and with the UK gaining experience in these areas were considered deliverable. Third party markets are unpredictable and are therefore judged as similar in performance to the ATT.

**Ability to Cope with Change**

The flexibility of each option to deal with changes in legislation, tonnage and composition was considered. Any thermal treatment technology will have an operational window- specifying the type of feedstock in terms of composition, size and calorific value. Thus there is less flexibility here than an option that can receive any type of waste. Like thermal combustion plant, AD plants are also constructed to accommodate a specific tonnage, which, once built, will require a minimum input tonnage and also have a maximum capacity. Option 1d scored well as it was considered to have the flexibility to play the RDF or composting markets. Modularity was considered, but modular solutions frequently have issues associated with their bankability. In general, by their very nature each waste management solution will have an element of inflexability against significant variation in tonnages etc; the only exception being landfill as this can be developed at the required rate.

The appraisal results for each indicator, as discussed above, are presented in Table5.2.

**Table 5.2 Appraisal Results**

| Indicator | 1a | 1b | 1c | 1d | 1e | 2a | 2b | 2c | 3 | 4 | 5a | 5b |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Resource depletion ($yr^{-1}$) | -1.10E+06 | -1.10E+06 | -1.23E+06 | -2.14E+06 | -8.16E+05 | -1.16E+06 | -1.25E+06 | -2.05E+06 | -1.18E+06 | 2.94E+05 | -1.46E+06 | -1.44E+06 |
| Emissions of greenhouse gases (g eq $CO_2$) | -1.22E+10 | -1.22E+10 | 3.65E+09 | -8.33E+09 | -5.70E+09 | -1.59E+10 | -2.51E+09 | -1.23E+10 | -5.08E+09 | -4.96E+09 | -1.73E+10 | 6.32E+09 |
| Emissions injurious to public health (g eq.1,4-DCB) | 1.67E+09 | 1.67E+09 | 4.00E+08 | 1.37E+09 | 7.97E+08 | 6.63E+08 | -2.45E+08 | 6.09E+08 | 2.18E+09 | 2.49E+09 | 1.17E+09 | -7.08E+08 |
| Eutrophication (g eq.$PO_4^{3-}$) | -1.46E+06 | -1.46E+06 | 1.56E+06 | 3.39E+06 | 1.18E+06 | 1.71E+07 | 1.95E+07 | 2.15E+07 | -1.50E+06 | -1.65E+06 | -1.96E+07 | -1.65E+07 |
| Extent of water pollution | 34 | 34 | 37 | 19 | 31 | 48 | 33 | 40 | 30 | 39 | 55 | 52 |
| Overall costs & Best Value (NPV £/T) | 43.67 | 43.24 | 43.9 | 41.35 | 41.12 | 48.53 | 40.28 | 47.36 | 34.67 | 29.56 | 43.01 | 45.53 |
| Likelihood of implementation within required timescales | 3 | 3 | 9 | 3 | 8 | 3 | 7 | 3 | 1 | 7 | 1 | 9 |
| Percentage of material recycled/composted | 10.7% | 10.7% | 10.7% | 10.7% | 33.2% | 3.1% | 3.1% | 3.1% | 3.2% | 0.0% | 11.2% | 11.2% |
| Percentage of material recovery | 48.3% | 48.3% | 0.0% | 48.3% | 0.0% | 60.4% | 60.4% | 60.4% | 84.5% | 99.0% | 68.0% | 0.0% |
| Reliability of technology | 1 | 1 | 8 | 4 | 7 | 1 | 5 | 4 | 1 | 9 | 1 | 2 |
| Minimise hazardous discharge to land (tonnes) | 1667.97 | 1667.97 | 0 | 1667.97 | 0 | 1253.64 | 0 | 1253.64 | 2920.23 | 3417.09 | 2347.47 | 0 |
| Ability to cope with change | 1 | 1 | 6 | 6 | 6 | 1 | 3 | 5 | 1 | 3 | 1 | 7 |

**Table 5.3 Scored results for each indicator**

| Indicator | 1a | 1b | 1c | 1d | 1e | 2a | 2b | 2c | 3 | 4 | 5a | 5b |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Resource depletion | 0.574 | 0.574 | 0.626 | 1.000 | 0.456 | 0.596 | 0.633 | 0.961 | 0.607 | 0.000 | 0.722 | 0.711 |
| Emissions of greenhouse gases | 0.781 | 0.781 | 0.113 | 0.619 | 0.508 | 0.939 | 0.373 | 0.786 | 0.482 | 0.477 | 1.000 | 0.000 |
| Emissions injurious to public health | 0.256 | 0.256 | 0.654 | 0.350 | 0.530 | 0.572 | 0.855 | 0.589 | 0.099 | 0.000 | 0.412 | 1.000 |
| Eutrophication | 0.558 | 0.558 | 0.485 | 0.440 | 0.494 | 0.106 | 0.047 | 0.000 | 0.559 | 0.563 | 1.000 | 0.924 |
| Extent of water pollution | 0.583 | 0.583 | 0.500 | 1.000 | 0.667 | 0.194 | 0.611 | 0.417 | 0.694 | 0.444 | 0.000 | 0.083 |
| Overall costs & Best Value | 0.256 | 0.279 | 0.244 | 0.378 | 0.391 | 0.000 | 0.435 | 0.062 | 0.731 | 1.000 | 0.291 | 0.158 |
| Likelihood of implementation within required timescales | 0.333 | 0.333 | 1.000 | 0.333 | 0.889 | 0.333 | 0.778 | 0.333 | 0.111 | 0.778 | 0.111 | 1.000 |
| Percentage of material recycled/composted | 0.323 | 0.323 | 0.323 | 0.323 | 1.000 | 0.094 | 0.094 | 0.094 | 0.097 | 0.000 | 0.339 | 0.339 |
| Percentage of material recovery | 0.488 | 0.488 | 0.000 | 0.488 | 0.000 | 0.610 | 0.610 | 0.610 | 0.854 | 1.000 | 0.686 | 0.000 |
| Reliability of technology | 0.000 | 0.111 | 0.889 | 0.444 | 0.778 | 0.000 | 0.556 | 0.444 | 0.000 | 1.000 | 0.000 | 0.222 |
| Minimise hazardous discharge to land | 0.512 | 0.512 | 1.000 | 0.512 | 1.000 | 0.633 | 1.000 | 0.633 | 0.145 | 0.000 | 0.313 | 1.000 |
| Ability to cope with change | 0.143 | 0.143 | 0.857 | 0.857 | 0.857 | 0.143 | 0.429 | 0.714 | 0.143 | 0.429 | 0.143 | 1.000 |

## 5.3 Scoring the indicators

The results from the appraisal exercise present the performance of each option against an indicator and this score is presented in the units used to quantify or measure the impact. Thus to "sum" the relative scores between options will require these appraisal result to be standardised to a scoring system that can allow for comparison. This can be achieved through scoring all outputs on a scoring system between 0 and 1. For each indicator, the best performing appraisal result is given the score of 1, the worst performing appraisal result 0. All the other results are given a score between 0 and 1 based on their relative positioning between the highest and lowest performing options. For example in the case of Resource Depletion, Option 4, the poorest performer scores 0. Option 1d, the highest performer scores 1. All other options are awarded a score dependent on their respective position between the scale established by Option 4 and Option 1d.

By adopting this scoring system the relative difference between option performances is retained for each indicator, whilst allowing the performance of the options against all indicators to be put on a common scale.

Scoring results have been calculated for each indicator in this manner and are presented in Table 5.3.

# 6. Weighting Indicators

## 6.1 Weighting Workshop

The second Waste Forum BPEO workshop was held on the 18th January at Milton Keynes Council Offices. The purpose of the workshop was to assign a weighting to each indicator, against which the scores from the evaluation stage would be multiplied.

Without weightings, all the indicators are of equal importance. In practice though, decision makers are likely to attach more importance to certain indicators than to others. The relative importance of the indicators can be reflected through applying "weightings" to each performance score. A simple approach is to provide decision makers with a number of points (100 for simplicity, as this can easily be translated into a percentage) and ask that these are distributed between indicators to reflect their relative significance.

At this second workshop, Entec presented the Waste Forum with an overview of the previous meeting and on progress to date with regard to appraising the indicators.

The 12 indicators used in the evaluation were presented to Forum Members, grouped under three headings, in an attempt to make their overall assessment objectives clearer. The three categories were:

- Environmental;
- Economics and Risk;
- Social.

The Environmental category includes indicators which highlight environmentally damaging considerations, Economics and Risk relating to indicators which assess the overall cost and deliverability of the options, and Social relating to factors which directly affect local people.

Entec had guidance on the assigning of weightings, and presented this to the Forum. Forum members were invited to discuss this approach and proposed their own suggestions. The eventual methodology was proposed and agreed by the Forum.

Prior to voting there was a discussion on each of the indicators, so Members could be sure as to what each indicator represented and assist them in making their decisions.

## 6.2 Voting Procedure

It was proposed that, in the first instance each Forum Member would allocate a weighting (the sum equalling 100) between the three categories. Members would then allocate a weighting (the sum equalling 100) to the indicators within each group. The weightings for individual indicators could then be calculated by multiplying the "within group" weighting by the "overall group" weighting.

The allocation was to be completed in two stages- firstly on the three categories. Individual Members allocation was summed and discussed, allowing Forum Members to debate the weightings assigned to the categories. Members then allocated weightings within categories. It was highlighted to members that, as the "Social" category only had one indicator, the weighting for the category would equal the weighting for the indicator.

After the initial between category allocation was presented. The result was:

| | |
|---|---|
| Environmental | 44% |
| Economics and Risk | 36% |
| Social | 20% |

Members debated the weightings. During the discussion it became apparent to all Forum Members that the indicator "Emissions injurious to public health" was likely to have twice the weighting of any other indicator. Forum Members also recognised that potentially not enough regard would be given to the affordability and the reliability of the technologies. The Forum, however, was also keen to ensure that Environmental concerns should not be sacrificed simply for economic reasons. Recognising the practicalities of financing and procuring reliable technologies, it was proposed that the Environmental and, Economics and Risk categories should have a similar weighting. However the Forum also wish to ensure that Environmental consideration really were at the forefront in the decision making process. Within these discussions an alternative category allocation was presented as:

| | |
|---|---|
| Environmental | 46% |
| Economics and Risk | 44% |
| Social | 10% |

With this allocation it was agreed that Environmental considerations retained their importance, whilst still being able to reflect the economic realities facing the Council.

Members proceeded to vote for within category allocations. These were summed and presented to members. Forum members were happy to accept the allocations as calculated. The within category allocations were:

| | |
|---|---|
| **ENVIRONMENTAL** | |
| Resource Depletion | 19 % |
| Percentage of Material Recycled/Composted | 19 % |
| Emission of Greenhouse Gases | 22 % |
| Eutophication | 6 % |
| Extent of Water Pollution | 8 % |
| Percentage of Material Recovery | 13 % |
| Minimise Hazardous Discharge to Land | 13 % |
| **ECONOMICS & RISK** | |
| Overall costs and best value | 27 % |
| Likelihood of implementation within required timescales | 21 % |
| Reliability of technology | 23 % |
| Ability to cope with change | 22 % |
| **SOCIAL** | |
| Emissions injurious to public health | 100 % |

Multiplying the “within” category weightings with the category weightings gives the individual weighting for each indicator. These are presented in Table 6.1.

**Table 6.1 Finalised Weightings**

| Indicator | Weighting (%) |
|---|---|
| Resource Depletion | 8.74 |
| Percentage of Material Recycled/Composted | 8.74 |
| Emission of Greenhouse Gases | 10.12 |
| Eutrophication | 2.76 |
| Extent of Water Pollution | 3.68 |
| Percentage of Material Recovery | 5.98 |
| Minimise Hazardous Discharge to Land | 5.98 |
| Overall costs and best value | 12.3 |
| Likelihood of implementation within required timescales | 9.7 |
| Reliability of technology | 11.4 |
| Ability to cope with change | 10.6 |
| Emissions injurious to public health | 10.0 |

# 7. BPEO Results

## 7.1 Results from scoring and weight exercises

Table 7.1 presents indicator scores and weighted scores, and Table 7.2 presents the Options ranked according to their weighted score.

**Table 7.1 Indicator Scores and Weighted Scores**

| | | Option 1a | Option 1b | Option 1c | Option 1d | Option 1e | Option 2a | Option 2b | Option 2c | Option 3 | Option 4 | Option 5a | Option 5b |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Resource Depletion | Score | 0.574 | 0.574 | 0.626 | 1.000 | 0.456 | 0.596 | 0.633 | 0.961 | 0.607 | 0.000 | 0.722 | 0.711 |
| Weighting: 0.0874 | Weighted score | 0.0502 | 0.0502 | 0.0547 | 0.0874 | 0.0398 | 0.0521 | 0.0553 | 0.0840 | 0.0531 | 0.0000 | 0.0631 | 0.0622 |
| % Material Recycled /Composted | Score | 0.323 | 0.323 | 0.323 | 0.323 | 1.000 | 0.094 | 0.094 | 0.094 | 0.097 | 0.000 | 0.339 | 0.339 |
| Weighting: 0.0874 | Weighted score | 0.0283 | 0.0283 | 0.0283 | 0.0283 | 0.0874 | 0.0082 | 0.0082 | 0.0082 | 0.0085 | 0.0000 | 0.0296 | 0.0296 |
| Emission Greenhouse gasses | Score | 0.781 | 0.781 | 0.113 | 0.619 | 0.508 | 0.939 | 0.373 | 0.786 | 0.482 | 0.477 | 1.000 | 0.000 |
| Weighting: 0.1012 | Weighted score | 0.0790 | 0.0790 | 0.0114 | 0.0627 | 0.0514 | 0.0950 | 0.0378 | 0.0795 | 0.0488 | 0.0483 | 0.1012 | 0.0000 |
| Eutrophication | Score | 0.558 | 0.558 | 0.485 | 0.440 | 0.494 | 0.106 | 0.047 | 0.000 | 0.559 | 0.563 | 1.000 | 0.924 |
| Weighting: 0.0276 | Weighted score | 0.0154 | 0.0154 | 0.0134 | 0.0121 | 0.0136 | 0.0029 | 0.0013 | 0.0000 | 0.0154 | 0.0155 | 0.0276 | 0.0255 |
| Extent of Water Polln | Score | 0.583 | 0.583 | 0.500 | 1.000 | 0.667 | 0.194 | 0.611 | 0.417 | 0.694 | 0.444 | 0.000 | 0.083 |
| Weighting: 0.0368 | Weighted score | 0.0215 | 0.0215 | 0.0184 | 0.0368 | 0.0245 | 0.0072 | 0.0225 | 0.0153 | 0.0256 | 0.0164 | 0.0000 | 0.0031 |
| % Material Recovery | Score | 0.488 | 0.488 | 0.000 | 0.488 | 0.000 | 0.610 | 0.610 | 0.610 | 0.854 | 1.000 | 0.686 | 0.000 |
| Weighting: 0.0598 | Weighted score | 0.0292 | 0.0292 | 0.0000 | 0.0292 | 0.0000 | 0.0365 | 0.0365 | 0.0365 | 0.0511 | 0.0598 | 0.0411 | 0.0000 |
| Min Haz discharge to land | Score | 0.512 | 0.512 | 1.000 | 0.512 | 1.000 | 0.633 | 1.000 | 0.633 | 0.145 | 0.000 | 0.313 | 1.000 |

| | | Option 1a | Option 1b | Option 1c | Option 1d | Option 1e | Option 2a | Option 2b | Option 2c | Option 3 | Option 4 | Option 5a | Option 5b |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weighting: 0.0598 | Weighted score | 0.0306 | 0.0306 | 0.0598 | 0.0306 | 0.0598 | 0.0379 | 0.0598 | 0.0379 | 0.0087 | 0.0000 | 0.0187 | 0.0598 |
| Overall cost & Best Value | Score | 0.256 | 0.279 | 0.244 | 0.378 | 0.391* | 0.000 | 0.435 | 0.062 | 0.731 | 1.000 | 0.291 | 0.158 |
| Weighting: 0.1230 | Weighted score | 0.0315 | 0.0343 | 0.0300 | 0.0466 | 0.0480 | 0.0000 | 0.0535 | 0.0076 | 0.0899 | 0.1230 | 0.0358 | 0.0195 |
| Likelihood of delivery within timescales | Score | 0.333 | 0.333 | 1.000 | 0.333 | 0.889 | 0.333 | 0.778 | 0.333 | 0.111 | 0.778 | 0.111 | 1.000 |
| Weighting: 0.097 | Weighted score | 0.0323 | 0.0323 | 0.0970 | 0.0323 | 0.0862 | 0.0323 | 0.0754 | 0.0323 | 0.0108 | 0.0754 | 0.0108 | 0.0970 |
| Reliability of technology | Score | 0.000 | 0.111 | 0.889 | 0.444 | 0.778 | 0.000 | 0.556 | 0.444 | 0.000 | 1.000 | 0.000 | 0.222 |
| Weighting: 0.114 | Weighted score | 0.0000 | 0.0127 | 0.1013 | 0.0507 | 0.0887 | 0.0000 | 0.0633 | 0.0507 | 0.0000 | 0.1140 | 0.0000 | 0.0253 |
| Ability to cope with change | Score | 0.143 | 0.143 | 0.857 | 0.857 | 0.857 | 0.143 | 0.429 | 0.714 | 0.143 | 0.429 | 0.143 | 1.000 |
| Weighting: 0.106 | Weighted score | 0.0151 | 0.0151 | 0.0909 | 0.0909 | 0.0909 | 0.0151 | 0.0454 | 0.0757 | 0.0151 | 0.0454 | 0.0151 | 0.1060 |
| Emissions injurious to public health | Score | 0.256 | 0.256 | 0.654 | 0.350 | 0.530 | 0.572 | 0.855 | 0.589 | 0.099 | 0.000 | 0.412 | 1.000 |
| Weighting: 0.1000 | Weighted score | 0.0256 | 0.0256 | 0.0654 | 0.0350 | 0.0530 | 0.0572 | 0.0855 | 0.0589 | 0.0099 | 0.0000 | 0.0412 | 0.1000 |
| **Total weighted score** | | 0.359 | 0.374 | 0.571 | 0.542 | 0.643 | 0.344 | 0.545 | 0.487 | 0.337 | 0.498 | 0.384 | 0.528 |

* The costings for Option 1e were provided by different consultants. These consultants costed two options, one to provide a ratio effect to allow Option 1e to be more realistically compared. Full details of this are provided in < >

**Table 7.2 Ranked Options According to Weighted Score**

| Option | Technology Option as described In Options Appraisal Report | Ranking |
|---|---|---|
| 1e | MBT + IVC (LATS compliant) + Lf | 1 |
| 1c | MBT + IVC + Lf | 2 |
| 2b | MT + AD + Lf | 3 |
| 1d | MBT + IVC +RDF (to 3rd party) | 4 |
| 5b | AC + Lf | 5 |
| 4 | EFW | 6 |
| 2c | MT +AD + RDF (to 3rd party) | 7 |
| 5a | AC + ATT | 8 |
| 1b | MBT + FBG +IVC | 9 |
| 1a | MBT + ATT + IVC | 10 |
| 2a | MT + ATT + AD | 11 |
| 3a | Screening and ATT | 12 |

It should be noted that transport impacts have not been included in this study. Markets for MBT residues will be governed by the contracts that can be secured at the time of procurement, and may change over the lifetime of the facility. This applies to markets for recyclables, any composted material and any RDF sent for 3rd party combustion. Low grade composted material from MBT plants may be landfilled, but would still attract landfill tax.

## 7.2 WET and LATS

The Waste and Emissions Trading (WET) Act 2003 allows the government to place restrictions on the amount of biodegradable waste sent to landfill by each Waste Disposal Authority. This Act is implemented in England through the Landfill Allowance Trading Scheme (LATS). This scheme will commence on April 1 2005. Under LATS all English waste disposal authorities will be issued with a number of landfill allowances, each of which permits the WDA to dispose of 1 tonne of biodegradable waste.

The issue of LATS compliance was discussed with the Council. It is the Council's intention to comply with LATS and as such a pass/fail has been applied on this issue. Options 1c, 2b and 5b fail to comply with LATS.

Using this pass /fail criterion amends the final result. The rankings are presented in Table 7.3

**Table 7.3 Option Rankings Post LATS Assessment**

| Option | Technology Option as described In Options Appraisal Report | Revised Ranking |
|---|---|---|
| 1e | MBT + IVC (LATS compliant) + Lf | 1 |
| 1d | MBT + IVC +RDF (to 3rd party) | 2 |
| 4 | EFW | 3 |
| 2c | MT +AD + RDF (to 3rd party) | 4 |
| 5a | AC + ATT | 5 |
| 1b | MBT + FBG +IVC | 6 |
| 1a | MBT + ATT + IVC | 7 |
| 2a | MT + ATT + AD | 8 |
| 3a | Screening and ATT | 9 |
| 1c | MBT + IVC + Lf | 10 |
| 2b | MT + AD + Lf | 11 |
| 5b | AC + Lf | 12 |

A number of assumptions have been used in this assessment. These assumptions are necessary to enable the completion of the assessment, and an indicative ranking to be formed. However the rankings should not be taken to sanction a particular option; rather their relative positions should identify a need to the Council to evaluate some schemes in greater detail, while others can be removed from consideration.

Options 1e and 1d, both MBT IVC's score well. The two options do represent different MBT technologies, Option 1e is focused on producing a LATS compliant stabalite that is either recovered or sent to landfill, while Option 1d is primarily a process that maximises the production of an RDF. Both these options will carry a different level of risk; Option 1e relies on the technology achieving the composting levels, whereas Option 1d relies on the development of 3rd party market for the RDF. If this market is not forthcoming then this option will not be realised during the procurement process. As discussed in section 5.2.3 there are risks associated with the performance of both of these technologies, particularly relating to their limited track record.

The next two options, Options 4 and 2c have close scores and both include combustion. Conventional combustion (direct combustion) features in four of the top five options, with the Advance Thermal Treatment (where a syngas is produced and subsequently combusted) (ATT and FBG), technology options all at the lower end of the table. Conventional combustion has fewer problems in raising project finance, as it is a well proven technology. However, it can have a negative image, often arising through mis-information or mis-understanding of the facts. This may be resolved through early, and well informed consultation, including discussion forums and workshops.

It is recommended the top performing technologies (MBT and conventional combustion) are further evaluated, including open, informed discussions between Officers, Members and the public.

# Appendix A
# Thermal Treatment Terminology

7 Pages

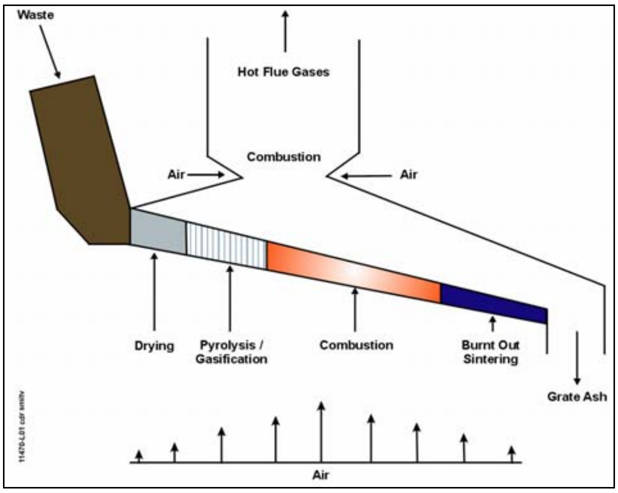
## A.1 Combustion Process

For clarification, the following terms are defined

**Conventional Combustion**: This term is commonly used to describe incineration processes in which the combustion of the waste stream occurs within a single vessel. The combustion process relies on the intimate mixing of the waste stream with air (which provides oxygen) at a high temperature. The combustible material is oxidised and, in the process, releases energy (heat) and the products of combustion in the form of gases. The incombustible material is removed from the process as an ash.

In fact, within the single combustion vessel, a range of processes are taking place, depending on the way in which the waste and air are introduced into the vessel, the composition of the waste, and the temperature profiles. To illustrate this point, Figure A1.1 presents, diagrammatically, the processes taking place in a conventional grate combustion furnace:

**Figure A1.1 Thermo-chemical Processes Within a Waste Incineration Furnace**




The hot flue gases are then, typically, passed through a steam-raising boiler, and the steam can then be used for the production of electricity or as a source of heat.

A range of technologies employ conventional combustion, including moving grate, rotating kilns and fluidised bed. These technologies differ mainly in how they achieve the contact of the waste stream with the air stream. Some of these technologies require, or benefit from, the pre-processing of wastes into a form such as RDF.

One form of Conventional Combustion is Mass Burn Incineration. This is commonly taken to mean the processing of MSW by means of conventional combustion with no or minimal pre-sorting of the waste stream. By virtue of the heterogeneous nature of the waste stream, mass burn incinerators tend to be based on moving-grate technology, which can process raw MSW more effectively. Over a dozen plants are currently operational within the UK including a number that have recently been commissioned in Hampshire.

**Advanced Thermal Technologies (ATT)**: This term is used to describe those technologies in which the various sub-processes that occur within conventional combustion are separated spatially, often with the intent of achieving a greater degree of control of the overall combustion process. The sub-processes comprise:

Pyrolysis: The thermal degradation of material to produce char, oils and fuel gas. Pyrolysis usually occurs in the absence of oxygen and requires heat to provide a temperature in the range of 400-800ºC to effect the thermal degradation.

Gasification: Uses a controlled amount of oxygen and/or steam to break down the long chain hydrocarbons in the waste to produce gases with an energy value such as hydrogen, carbon monoxide and methane.

Oxidation: The combination of oxygen (usually supplied by a stream of air) with the products of pyrolysis or gasification resulting in the release of thermal energy or work.

The *potential* advantages of ATTs include the greater control that can be achieved in each of the thermo-chemical processes, and the potential for increasing the overall efficiency of conversion to electricity through the use of internal combustion engines as prime movers rather than steam turbines.

There is a wide range of types of ATT, with different combinations of pyrolysis, gasification and oxidation. Furthermore, there are a wide range of different types of vessel in which these thermo-chemical processes take place. For instance, just as in a combustion process, gasification can take place on a grate, in a kiln, or in a fluidised bed. The term "fluidised bed gasification" therefore, is just one type of ATT that aims to produce a 'fuel gas' from the feed waste material. As with all types of fluidised bed process, fluidised bed gasification requires the pre-processing of any raw waste stream to provide a consistent feed material, particularly in terms of particle size and calorific value

## A.2 Process Features : Conventional Combustion & Pyrolysis-Gasification

This section has been compiled in order to draw out the similarities and differences between the two main thermal processing techniques described above (Conventional Combustion or ATTs).

Irrespective of the technique employed, thermal processing of waste results in:

- Release of thermal energy or work
- Production of a flue gas comprising the gaseous products of combustion and the gases introduced into the process with the oxygen used in the combustion process
- Reduction of the non-volatile content of the waste stream into an ash.

The principal differences between the two techniques derive mainly from the configuration of the two processes:

Plant Configuration : Conventional Combustion

A conventional combustor will receive the waste stream into a furnace. The furnace will operate at a temperature in the range of typically 850-1300ºC. Oxygen present in air introduced into the furnace will react with the waste, resulting in release of energy, production of gaseous by-products and reduction of the non-volatile components of the waste into ash.

A number of different types of furnace are possible – the three principal types being grate-based combustion, kilns and fluidised beds. The characteristics of grates and kilns a broadly similar, in that waste is introduced at the top of the grate or kiln and moves down the grate or kiln as it burns. Fluidised beds are different in a number of respects:

- They require a more sophisticated fuel feed system with a more homogenous feedstock (which may not be a problem for heavily pre-treated waste such as RDF);
- They can incorporate in-bed reagents for control of pollutant emissions
- They can have inherently lower $NO_x$ emissions
- They tend to be more sensitive to load variations.

Following the combustion furnace, the hot product gases will flow into a heat recovery section (usually integrated with the furnace) where the gases will be cooled by passing across water-cooled or steam-filled tubes. The heat recovery section will produce superheated steam that can be used to drive a steam turbine and produce electricity. Low pressure steam extracted or ejected from the steam turbine can be used in local applications requiring heat (CHP applications).

The cooled product gases are then passed through a flue gas treatment system in which the gas is contacted with reagents that remove contaminants prior to the emission of the flue gas to atmosphere. The flue gas treatment process creates an additional, but small, flow of spent reagents that will require subsequent careful disposal.

<u>Plant Configuration : ATTs</u>

In a pyrolysis-based advanced thermal process, the waste stream is introduced into a heated vessel - the pryolyser. The waste stream passes through the heated vessel and thermally decomposes producing a mixture of gas, oils, tars and char. The solid or liquid products of pyrolysis can then be presented to a conventional combustor or proceed to a gasification stage. The gas can be used as described below for gasification.

In a gasifier, the waste (or, if preceded by a pyrolysis step, the pyrolysis products) will be reacted at a high temperature with a small amount of oxygen (insufficient to fully combust the products) or steam to convert the products into a **fuel** gas. Some technology suppliers introduce pure oxygen or high oxygen-content air to achieve a temperature within the gasifier that is sufficiently high to melt the solid ash residue, resulting, on cooling, in a vitrified solid. Gasifiers relying on air or steam will produce an ash residue, similar to that produced in a conventional combustor. The use of oxygen or oxygen-enriched air also increases the calorific value of the fuel gas. The product fuel gas produced in the gasifier can then pass on to a simple gas furnace or to a gas engine.

In a gas furnace, the fuel gas produced in the gasifier combines with oxygen (present in the air introduced into the furnace) resulting in the release of energy and production of gaseous by-products. Depending on the nature of the waste stream and the gasification technology, some pre-treatment of the fuel gas may be needed to limit corrosion or wear in the furnace or downstream plant. This cleaning step will lead to the production of a liquid effluent and solid wastes, which will need careful treatment and disposal.

The hot gases then pass into heat recovery and flue gas treatment stages, similar in concept and design to those used in conventional combustion systems. If extensive gas cleaning takes place upstream of the furnace, there may not be a need for much flue gas treatment downstream of the furnace to achieve permissible levels of exhaust gas emissions. If used, any flue gas treatment will be very similar to that employed in a conventional combustion system, and it will lead to the production of a spent reagent waste stream. Such a process configuration is sometimes termed a 'heat' gasification process.

Alternatively, the fuel gas from the gasifier can pass into an engine (reciprocating or gas turbine) where it is ignited, resulting in work that drives a turbo-alternator to produce electricity. In such a configuration, more substantial clean-up of the fuel gas is required prior to entry into the engine in order to prevent damage to the moving parts within the engine. As with a 'heat' gasification process, any fuel gas cleaning will lead to the production of effluents that will require subsequent disposal. Furthermore, some exhaust gas treatment may also be needed downstream of the engine in order to comply with air emissions requirements – this too can lead to the production of solid or liquid waste streams. This arrangement is conventionally termed a 'power' gasification system. As yet, there are no examples of such 'power' gasification systems with a long-term history of operating on mixed municipal waste feedstocks.

Due to the additional complexity, cost and technical risk associated with a 'power' gasification system, **many suppliers of advanced thermal technologies currently tend to couple their technology with a conventional steam cycle in a 'heat' gasification process**.

Some suppliers of ATTs promote the concept that they can extract the gasifier product gas and use it as a feedstock for processes producing materials such as hydrogen, methanol or ammonia. Whilst this is commonplace in the petro-chemical industry where the feedstock (crude oil) is homogenous, it is not yet a proven concept on waste pyrolysis-gasification processes.

### A.3 Electrical Conversion Efficiency

In a conventional combustion plant, electrical energy is recovered from the hot combustion gases by means of a steam boiler and steam turbine; this is termed a steam cycle. In a pyrolysis-gasification plant, energy can also be recovered in this way or by directing the fuel gas to a gas engine or turbine.

#### Conventional Combustion

A steam cycle configuration will typically deliver about 20-25% recovery of the energy in the waste in the form of electricity (on a lower calorific value basis). The actual efficiency depends upon the degree of release of energy from the waste stream, the scale of the plant, and the design of the boiler and flue gas treatment system.

#### Pyrolysis-Gasification

For a pyrolysis-gasification system using a steam cycle, the overall electrical conversion efficiency will be different to that of the equivalent conventional combustion plant, due to the different process configuration. Whilst the boiler efficiency may be slightly higher due to, for instance, a lower requirement for soot-blowing the boiler tubes, the overall process efficiency is likely to be less due to the additional energy losses associated with the pyrolysis-gasification steps prior to the boiler.

A pyrolysis-gasification system configured with a gas engine or turbine does, however, provide a potentially higher electrical energy recovery efficiency, due to the nature of the machines. Typically, the electrical conversion efficiency of a reciprocating spark ignition gas engine may be in the range of 35 - 40%. However, one must also take into account the energy losses in the pyrolysis-gasification stages upstream of the engine. Furthermore, the cleaning of the fuel gas from the pyrolysis-gasifier will include a cooling step – a process in which additional energy is lost. Overall, the electrical conversion efficiency of a pyrolysis-gasification process when using reciprocating internal combustion engines is estimated to be in the range of 25 - 30% on a lower calorific value basis.

### A.4 Emissions to Atmosphere

There is a general perception that ATTs can achieve lower emissions than can conventional combustion technologies. In fact, flue gas treatment techniques are such that the same abatement equipment can be installed on both technologies, thereby enabling, in principle, similar levels of pollution abatement to be achieved.

Having said that the achievable emissions levels are similar given flue gas treatment, if the pollutant load or the volume of flue gas to be treated differs between the two processes then there may be a capital and operating cost implication that will ultimately reflect in the gate fee offered. Some suppliers of advanced thermal technologies are known to claim that they can achieve lower pre-gas cleanup pollutant levels than might a conventional combustor and so they consider that their clean-up costs will be commensurately lower. This can only be properly tested by a formal tendering process.

Some of the advanced technology suppliers also claim that by separating the pyrolysis, gasification and oxidation stages that occur in conventional combustors they can achieve greater control of pollutants such as dioxins at the point of production.

However, there is limited data available to fully validate the claims of advanced technology suppliers on their ability to limit dioxin formation. Indeed, the Environment Agency stated in their draft guidance document, "IPPC S5.01 Interim Sector Guidance For The Incineration Of Waste And Fuel Manufacture From Or Including Waste", July 2001, that "There would appear to be little evidence to support claims that pyrolysis and gasification emit lower amounts of dioxins to air than modern incinerators".

Furthermore, a recent review of research literature undertaken for DEFRA[3] reports that "there is very little published data on emissions from pyrolysis and gasification systems and that there are limitations associated with the data that is available".

It should be noted that the required emission levels for *any* proposed plant will be set by the Environment Agency through the IPPC Authorisation process and will be based on their understanding of the performance achievable by Best Available Techniques (BAT), by the minimum requirements set by the European Waste Incineration Directive (WID) 2000/76/EC and by local air quality requirements.

---

[3] "Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes." DEFRA.

## A.5 Deliverability

The 'deliverability' of a project based on a particular technology is a complex mixture of economics and risk management.

### A.5.1 Economics

There are very few reliable data that present real project costs for EfW plant based on ATTs. Most cost data are projections and estimates, based on feasibilities, or pilot-plant scale-up, rather than on actual built costs of operating projects.

There are many factors that must be considered when analysing cost data:

- It is very difficult to estimate the true costs of technologies until several projects have been fully constructed and taken over by a purchaser.
- Suppliers of advanced technologies tend to have limited commercial supply experience and, consequently, limited capital and operating costs data. Also their designs for larger scale plant may not have been fully engineered to a sufficient level to enable them to obtain robust supply costs information and so proposed prices may be unreliable.
- Most of the smaller suppliers tend to promulgate headline prices that cover only the supply of their plant and fail to address the full project costs required to deliver a complete EfW facility, for example, civil works, road and electricity connection infrastructure, buildings etc that can constitute 20-40% of the total project costs.
- Many suppliers of novel technologies are highly optimistic about annual plant maintenance costs, often quoting a typical 3 - 5% of the plant capital cost pa as an indicative figure. Actual operating experience often reveals that maintenance costs can be significantly above this level (5 - 10%).
- Most headline prices tend to be 'risk-free', that is the supplier has not included for any premiums that might have to be applied to provide the appropriate levels of recourse sought by the purchaser or contingency required by the supplier to cover for guarantee commitments.

### A.5.2 Risks

The risks in the development of an EfW project include a wide array of issues, including waste contracting, waste composition, planning, permitting, technology, construction and finance.

A number of projects using ATTs have, in recent years, successfully achieved planning permission, but have not been successfully built. The principal reason for this is the challenge of creating a 'bankable' project structure.

The recent history of developing EfW projects based on ATTs has seen some very notable technical and commercial difficulties, such as those associated with the EDL/SWERF technology in Australia (EDL terminating further development and writing off some £40m of development investment) and the even more recent difficulties with the Thermoselect project in Karlsruhe (in 2004 the management board of EnBW Energie Baden-Württemberg AG announced their decision to withdraw from the Thermoselect project in Karlsruhe). These projects underline the fact that there are very few EfW projects using ATTs that have a long-term track record of operating success.

A local authority has a number of priorities in the development of waste management solutions. Compliance with the waste management hierarchy, achievement of recycling, composting and recovery goals, environmental performance, and cost are all vital. Of great importance, also, is the reliability of the technologies used as part of an integrated waste management solution. This issue of technical efficacy and reliability is of critical importance to all stakeholders in any project – it is a key risk area that any project investors will want to be effectively managed.

Even if a technology can be shown to have some operating track record on the fuel proposed for a particular project, an investor (lender or equity) is still likely to need a technology provider or project contractor to provide robust guarantees to protect revenues associated with the performance and reliability of the project. So not only is a technical track record needed, so too is a bankable guarantee from a robust commercial organisation. Banks are very unlikely to accept performance risks sitting in the project – such risks must be borne by the sponsor, the technology provider or the contractor.

ATTs are the subject of much development work. Many gasification and pyrolysis technologies have been successfully used on a wide range of feedstocks, but there are only a few that have operated on mixed solid wastes. Where there *are* commercial case-studies with track record, they tend to be ‘heat’ gasification or pyrolysis systems in which not all of the *potential* environmental or efficiency advantages of ATTs have been captured.

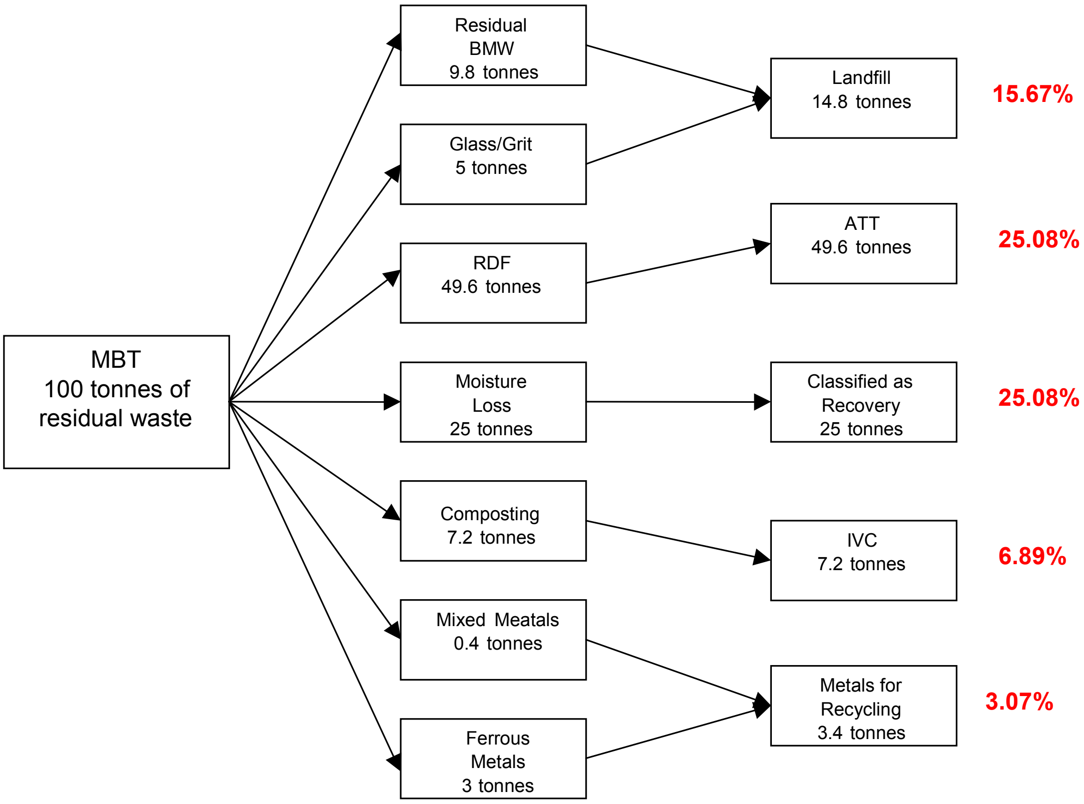
DEFRA has recently launched the New Technologies Programme, which is a capital grants scheme aimed at supporting the commercial demonstration of a range of new waste processing technologies (or, at least, technologies that are new to the UK). A number of projects using ATTs are expected to receive capital grants over the course of the next 6-12 months. If these projects successfully demonstrate the efficacy and reliability of the technologies, the programme may make an important contribution to overcoming this ‘bankability’ hurdle. The effect of this programme is unlikely, however, to have a significant impact in the near term.

To date, there are no examples of any projects using ATTs in the UK that have successfully secured significant debt finance.

# Appendix B
# Technology Mass Flows

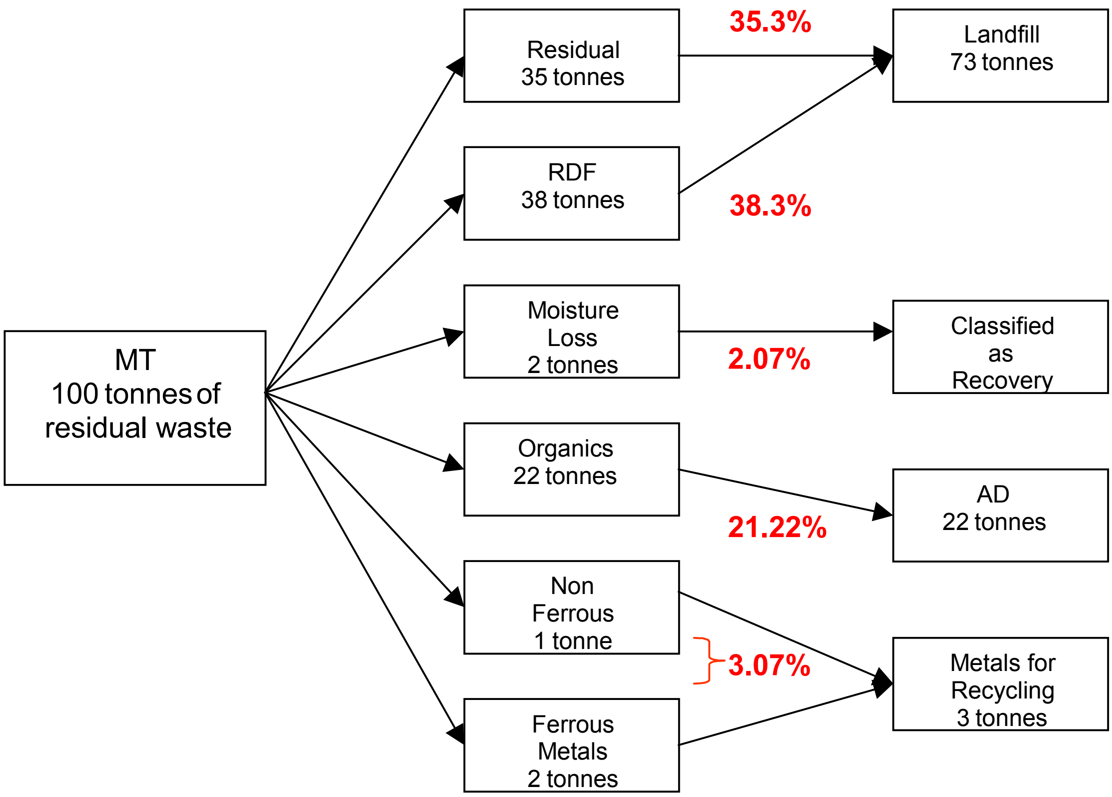
5 Pages

**Figure B1 Option1A - D, Mechanical Treatment, In-vessel Composting of Waste and Production of RDF**



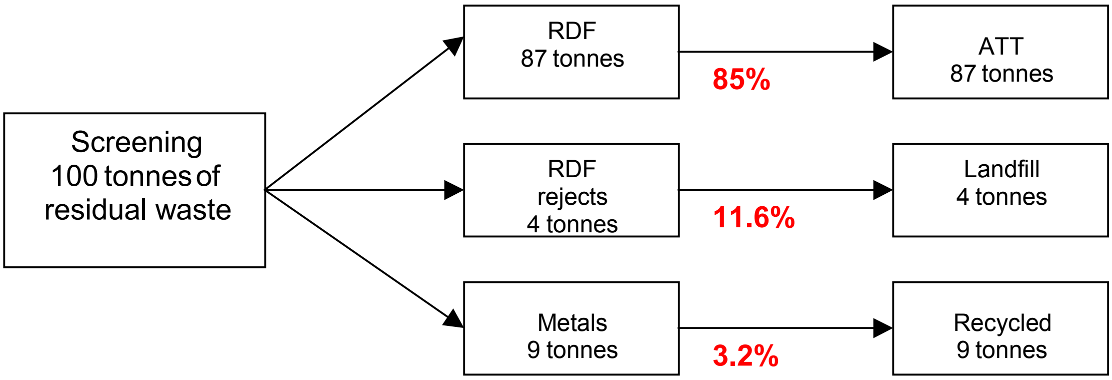

**Please note:**
The mass flows are taken from Option Appraisal Report.
The figures in red are calculated flows for Entec's Mass Flow Model for use in the WISARD Assessment.

**Figure B2 Option 2A - C Mechanical Treatment, Anaerobic Digestion of the Biological Fraction and Production of an RDF**



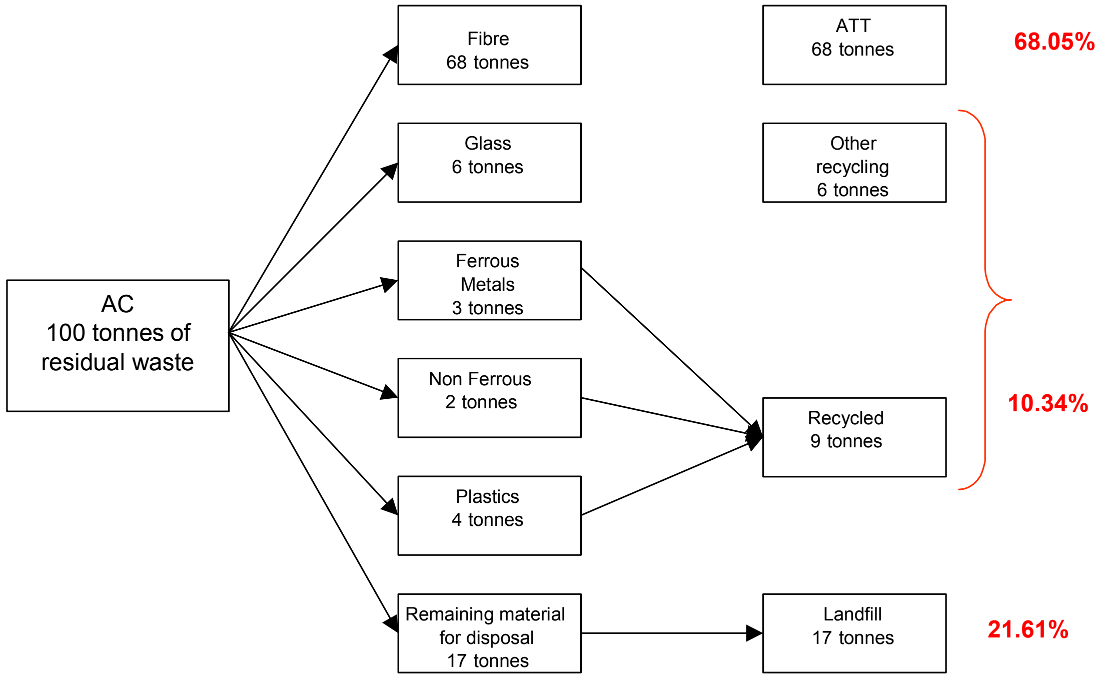

**Please note:**
The mass flows are taken from Option Appraisal Report.
The figures in red are calculated flows from Entec's Mass Flow Model for use in the WISARD Assessment.

**Figure B3 Option 3, Screening and Advanced Thermal Treatment**




**Please note:**
The mass flows are taken from Option Appraisal Report.
The figures in red are calculated flows from Entec's Mass Flow model for use in the WISARD Assessment.

**Figure B4 Option 5, Autoclave Screening and Residual Treatment**




**Please note:**
The mass flows are taken from Option Appraisal Report.
The figures in red are calculated flows from Entec's Mass Flow Model for use in the WISARD Assessment.

**Figure B5 Option 4, Screening and Energy From Waste Recovery**