# "MBT/BMT Technologies: An Overview for Dealing with Residual Municipal Waste in the UK : Opportunities and Barriers"

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## Executive Summary

Considerable interest has been expressed in the UK in 2002/03 in new technologies for dealing with residual wastes. Often called Mechanical and Biological Treatment (MBT), there is no single 'technology' but they include a mix of pre-processing operations, mechanical and/or biological treatment and a variety of product 'outputs'.

The two main products outputs are either a stabilised waste or a dry fibre for use as a fuel. The former is supported by environmental groups, whilst the latter is criticised as being 'incineration by another name'. Doncaster and Byker pioneered such an approach producing Refuse Derived Fuel (RDF) in the UK in the 1980s. Whilst most MBT plants focus on residual municipal/household waste, some are involved with this waste stream and also liquid wastes from sewage works - offering both operational and output product advantages.

This Paper[1] reviews the characteristics of technologies currently available or being considered in the UK, draws together public domain data on mass balances and costs and reviews the opportunities and barriers for Local Authorities considering them as part of their waste management strategies. Key opportunities are their modular nature, and thus flexibility, together with how they fit within a 'three-stream' system of maximising recycling and pre-treating residual waste rather than opting for expensive long term incineration contracts or landfill. Barriers include cost, unproven technology (in the UK), possible public opposition and lack of public domain data on mass balances, costs and emissions.

With the targets posed by the Landfill Directive to treat/divert biodegradable wastes from landfill, such technologies may offer valid options within integrated and sustainable waste management strategies. They may, however, conflict with high recycling targets and if they only produce 'stabilised waste' or 'fuel feedstock' they may not solve problems as easily as their advocates claim.

The establishment of Workstream Three under Defra's Waste Implementation Programme during 2003, covering New Technologies, is urgently required to provide impartial advice to Local Authorities on the potential role that technology transfer from long-established use (up to ten years in some cases) in other countries can offer the UK. This has to cover economics and commercial risk, environmental and health protection, operational reliability towards the Landfill Directive deadline of 2020 and the political risk to Local Authorities in opting to use such new (for the UK) technologies.

Decisions will also have to be taken, at EU and UK levels, to clarify the definitions of various terms. These not only include the definitions of waste, recycling and recovery but also clarification of the terms stabilisation and sanitisation and acceptable and verifiable methods of measurement. Where the technologies claim 'products' are outputs rather than wastes, then these must fit agreed (and statutory ?) fit-for-purpose product specifications.

During 2002/03 a number of new acronyms have appeared in waste literature in the UK, associated with new trade names and companies promoting their use. The most common is MBT (Mechanical and Biological Treatment), although BMT (Biological and Mechanical Treatment) or BioMR$^2$F (Biological Material Recycling and Recovery Facility) and the more general MPT (Mechanical and Biological Pre-Treatment) is also used. This Paper is an overview of these developments, focusing on developments in England and Wales and does not intend to give a detailed review of individual technologies.

For the purposes of this Paper, the terms MBT and BMT are used :

- MBT involving a front-end MRF and processing followed by anaerobic digestion or in-vessel composting, with the stabilised output going to landfill.

- BMT involving initial drying of the waste inputs, MRF and processing followed by pyrolysis and/or gasification, or anaerobic digestion or secondary product development.

Both may involve 'front-end' autoclaves for initial steam-based sanitisation and drying. Both might best be termed 'technology systems' with various component modules, based on pre-treatment of waste inputs (may include the use of autoclaves), operational processes, output product refinement and technology(ies) to use outputs. Each of these component parts may include more than one technology and more than one supplier. Essex County Council uses the term ‘MBT families’.

| | |
|---|---|
| • waste inputs : | municipal solid waste, household waste, commercial and industrial waste |
| | mixed (with no source segregation) or residual (with source segregation of dry recyclables and/or green wastes) |
| • pre-treatment | separating out bulky items |
| | trommel for size separation |
| | autoclaving/sterilising |
| • material outputs | dry recyclables |
| | wet fibre for biowaste treatment |
| | dry fibre for RDF/SRF |
| | dry fibre for secondary raw materials |
| • residual waste | for landfill |

Interest in such 'new' technologies has emerged alongside reports that recycling/composting in England and Wales and reached c. 12% in 2000/01 with Local Authorities in England now tasked with statutory Best Value Performance Indicators for 2003/04 and 2005/06 - intended to meet overall aspirational targets of 17% and 25% respectively set down in *Waste Strategy 2000*. A higher recycling target of 30% was set for 2010 and 33% in 2015. Recovery targets (including recycling/composting and energy recovery) for 2005, 210 and 2015 are 40%, 45% and 67% respectively. The Strategy Unit in November 2002, *Waste not, want not*, proposed a new recycling target of 45% for England for 2015.

With the publication of the waste strategy for Wales, *Wise About Waste,* in June 2002 these national targets now apply to England only.

The definition of recycling was tightened in January 2003 with guidance on Local Authority Best Value Performance Indicators for 2003/04 published by the Office of the Deputy Prime Minister :-

BV 82a Percentage of the total tonnage of household waste arisings which have been recycled

> 'Recycled' means reprocessed in a production process for the original purpose, or for other purposes, but excluding energy recovery. Waste recycled to form compost should only be included under BV 82b

The *National Waste Plan for Scotland* in March 2003 includes a combined target of 55% by 2020, comprising a recycling target of 35% and a composting target of 20% . This compares with an 'interim' target for recycling/composting of 25% for 2006 set down in *Building a Better Scotland* and *Building a Sustainable Scotland*. Each target is based on municipal waste , i.e. collected by Local Authorities, and thus different to the definition in the Landfill Directive. Materials for recycling/composting 'must be capable of being recovered in a form in which they can be used'. Wales is unique in the UK in using the Landfill Directive definition of municipal waste in contrast to a more restricted definition by England and Scotland. Recycling/composting targets in Wales have been set for municipal waste : at least 15% for 2003/04, 25% for 2006/07, 40% for 2009/10 - in each case with minimum composting targets of 5%, 10% and 15% respectively.

Incineration, with or without energy recovery, was a key component for over thirty Local Authorities in the UK until 1996 when the Municipal Waste Incineration Directives (89/369/EEC and 89/429/EEC) led to the closure of c.30 older and inefficient mass burn incineration plants. Some were upgraded and retro-fitted with new emission control systems, and there are now (Summer 2003, source Environmental Services Association) 15 operational mass burn municipal waste incinerators, two RDF waste-to-energy plants, two under construction. In addition, six have planning permission and 15 are going through planning/licensing procedures – recent examples to obtain planning permission and Environment Agency IPPC regulatory approval included Maidstone September 2003, and Grundon's in Slough in early 2004. Sita plans for an incinerator in Aberdeen were turned down in February 2004.

However, at the EU level, in connection with the definition of 'recovery, the Reasoned Opinion of the European Court of Justice Advocate-General Jacobs of the European Court of Justice, Commission v, Germany (C-228/00) on the shipment of waste, delivered in September 2002 stated :-

- the use of mixed waste in cement factories must be classed as a recovery operation, based on the concept of using waste as a fuel and replacing energy from other primary sources. The operation would still occur in the absence of available waste.

- the burning of municipal waste in incinerators, even with the recovery of energy, cannot be classified as 'recovery' and is a disposal operation, which would cease if there is no available waste.

Under the 1975 Waste Framework Directive (75/442/EEC) 'disposal' is defined as operations included in Annex IIA which include, *inter alia*, "incineration on land (D10)", while the recovery operations listed in Annex IIB include "use principally as a fuel or other means to generate energy (R1)".

This was confirmed by the European Court of Justice in February 2003. On the same day, the Court also confirmed judgement in a separate case, Commission c. Luxembourg (C-458/00), that waste sent from Luxembourg to a municipal incinerator (with energy recovery) in France was disposal and not recovery

In May 2003 the European Commission agreed with the 'Luxembourg' judgement, in response to written question from a MEP. The Commission response made reference to the **principal/primary objective** of a municipal incinerator being to dispose of waste. The EU executive stated that " by applying the concept of the primary objective of the operation, (the court has) excluded dedicated incineration in municipal incinerators" from the EU Waste Framework Directive (WFD) list of recovery operations.. The Packaging Directive draws its definitions from the WFD, but also by implication, the ELV and WEEE Directives.

In December 2003 a working document of the conciliation process between the European Council, Parliament and Commission proposed a new version of Article 6, paragraph 1(b) of the Packaging Directive 94/62/EC, and this was include in the amended Packaging Directive 04/12/EC :-

> "No later than 31 December 2008, 60% as a minimum be weight of packaging waste will be recovered **or incinerated at waste incineration plants with energy recovery**". (new text emphasised).

Despite this change, and alongside the Luxembourg judgement, many Local Authorities have been, and are likely to be, looking at alternative technologies to bridge the gap between recycling/composting, residual waste management and disposal. Recommendations in the Strategy Unit Report proposed that DEFRA and DTI should take forward a programme of development of new technologies, including pilots for more innovative waste management practices in partnership with industry and Local Authorities. The potential role of new and viable technologies for waste management was also mentioned in the 2003 Budget.

Grants for pump-priming projects may help, but will require careful targeting - by waste stream, technology and delivery stakeholders. If established, a Technology Board (proposed in the Strategy Unit Report) will need to be independent, and its decisions seen to be transparent. The waste management industry is increasingly characterised by larger companies, with many of them having multi-national scale operations. The issues here are ones of balancing profit and risk, length of contracts and facilitating technology transfer in the short- to medium-term rather than focusing purely on longer-term new technology. The Leicester MBT project, referred to below, is the subject of £30 million of credits from the Private Finance Initiative (PFI) over the 25 year life of the contract. This will be delivered through a 'special purpose vehicle' - Biffa Leicester Ltd - with the main construction provided by Biffa Waste Services and Severn Trent Water Ltd, the latter as parent company providing corporate debt. East London Waste Authority has been awarded £47 million under PFI in partnership with Shanks East London including ecodeco (BMT) plants at two separate locations.

PFI as a whole has been slow to take off with reference to waste projects. As at September 2003 only 8 projects had been contractually agreed, with a further six in the pipeline. This is despite a big increase in the availability of credits, from £200 million in 2000 to £478 million in 2003.

Although different technologies are used, with different levels of complexity and throughput systems with different outputs they all have similar characteristics. They take mixed (residual) wastes from household and/or commercial sources and through various screening, conditioning and sanitising processes extract recyclable materials and produce a stabilised waste (MBT) potentially suitable for meeting the diversion targets of biodegradable waste laid down in the Landfill Directive. Alternatively, from BMT plants, a fuel-rich dry stabilate or Refuse Derived Fuel (RDF - now also called Solid Recovered Fuel (SRF) is produced. This can be used in co-incineration plants such as cement kilns, power stations, petrochemical plants, steelworks or in new technologies such as pyrolysis/gasification (see Annex 3). The technologies offer a potential range of options for dealing with residual waste as part of both a broader and specific approach to integrated and sustainable waste management, although they require a range of pre- and back-end treatments to be fully effective.

It is these 'front- and back-end technologies' linked with MRF-type operations which distinguish them from the Dano drum system which has been used by some Local Authorities for many years to 'treat' mixed waste by pulverising/segregating wastes of different sizes in a large trommel, usually as a waste transfer station operation. In some cases pulverising/pulping the small-size (organic rich via 50 mm screen) fraction over a longer retention time results in an organic-rich output - although the process is still considered as treatment and not recovery (see Annex 1), with the output material still regarded as waste and not 'compost'. The use of RDF/SRF, however, would probably qualify as 'recovery' where it displaces other fuels, assuming the UK adopts the European Court of Justice ruling.

For Local Authorities preparing waste management strategies new MBT/BMT-type technologies offer a potentially flexible way of dealing with residual waste alongside kerbside collection of dry recyclables and organics and/or bank recycling and - described by some writers as a 'three-stream strategy'. In 2000/01 the UK recycling rate was 12%, with an overall residual waste fraction in the UK of nearly 88%, with 78% being landfilled and 10% being incinerated. As national and local recycling/composting targets are met, this residual proportion will fall (although increases in absolute tonnages are expected) and the big debate is how to meet source separation and treatment/diversion targets of the Landfill Directive. In particular, without pursuing a policy of building large inflexible municipal incinerators tied to long-term contracts, or seeking new landfill sites (but requiring per-treatment of wastes), with both subject to increasing public opposition related to NIMBYism.

**Table 1 : Conversion Technologies - MBT/BMT - in use/proposed in the UK**

| Trade name | Country of origin | UK company | Local Authority |
|---|---|---|---|
| Dano Drum | Denmark | | Manchester |
| SWERF | Australia | Brightstar, Brett | Derby, Canterbury |
| Ecodeco/Biocubi[1] | Italy | Shanks | East London, Milton Keynes, Dumfries + Galloway |
| Thermsave[2] | UK | Davies Bros | Bridgend |
| Grupo HLC | Portugal | Henley Burrowes | Neath Port Talbot, Wrexham ? |
| Kinetic Streamer | | Wastec | Stockton |
| Hese Umwelt | Germany | Biffa | Leicester |
| Herhof | Germany | | Expressions of interest Lancashire preferred bidder |
| Compact Power | | | Avonmouth (pyrolysis/gasification |
| farmatic | Germany | | Holsworthy (anaerobic digestion) |

… and other technologies not yet in the UK

1. Shanks use the term 'Intelligent Transfer Station' in the UK.
2. This plant was linked with Remtec (originating in the USA), but technology is now UK-patented.

The last two companies in the table are concerned specifically with operational ‘back-end’ applications in the UK providing specific output products.

Other ‘MBT’ plants exist as R&D projects such as an ‘aerobic digester’ plant in County Durham, funded through the landfill tax credits scheme, with a design input of 8,000 tonnes per annum.

A number of pilot plants have been established specifically to treat catering/kitchen wastes and include Greenfinch, ETT, inetec, Vital Earth Group and pilots being managed by companies such as Cleanaway and Sita.

At June 2004 it seems some of the big international players (e.g. Ebara, Mitsui Babcock, Thermoselect) have not yet moved into the UK in a visible way. A listing of known technologies, existing or planned, with potential for the UK are given at the end of the Paper under ‘Contacts’.

In January 2004 Herhof Environmental (UK) were confirmed as the preferred bidder to build a pioneering experimental MBT plant. This plant will be funded by the Lancashire partnership, without PFI, and act as a trial run. If successful, three more MBT facilities will be built with help from the £110 million PFI contract given the go-ahead in November 2003.

**Opportunities**

Depending on the mix of technologies, such approaches deal with residual mixed wastes and extract various materials as 'resources'. Suppliers promote flexibility in terms of modular construction, with differing front-end/middle/back-end technologies, offering input capacities ranging from 10-200,000 tonnes, and in some cases much larger capacities. As an example, the Shanks proposal for Milton Keynes included up to ten, subsequently reduced to four units, each of 60,000 tonnes. The proposal for Dumfries and Galloway is for one unit, due to become operational in 2004. All operations normally take place in enclosed buildings, comparable to large factories or warehouses, with land requirements being typically 60-70 $m^2$ per 1,000 tonnes per annum capacity. A typical plant of 60,000 tonnes would require c. 2 hectares, compared to 0.5 hectares for an in-vessel composting plant and 4 hectares for an open windrow composting system

A front-end 'dirty' material recovery facility (MRF) receiving co-mingled household/municipal waste might be included with an MBT, with non-recyclable waste accounting for up to 50% of input going to the next stage. The Wastec plant quotes a 70% 'recycling/recovery' rate, through including contaminated paper offered for use as a fuel and organic waste for further processing. An alternative is to have a (parallel) 'clean' MRF separating dry recyclables from kerbside and/or drop-off/bring schemes, with a non-recyclable residual waste figure of 5-20%.

Subsequent processing in an MBT, usually involving sorting and/or shredding and/or ball mill operations, leads to moisture reduction, although the biodegradable waste retains more moisture than with BMT processes. Converting such 'dirty' or 'grey' waste though such processing, and perhaps disposal to landfill, would be an option favoured by environmental groups such as Greenpeace, as a transitional technology on the road to the visionary 'zero waste'. However, whether such outputs would count as recycling/composting is still to be confirmed. With anaerobic digestion or in-vessel composting the waste becomes 'stabilised' (and methane to generate electricity) – potentially meeting the diversion requirements of the Landfill Directive, although meeting the limit value of 5% Total Organic Carbon has yet to be determined ?

However, this might lead to public opposition and planning permission problems as illustrated in a 20,000 tonne composting plant being rejected in August 2002. The Leicester project has a front-end dirty MRF planned to yield 5% metals, up to 40% paper and plastics (for use as a fuel), 35% organic material (@34-40% dry solids for AD) and the residual 20% sent to landfill. The organic fraction will be sent to a new AD facility at Wanlip, operated by Severn Trent Water (parent company of Biffa), to produce biogas and an agricultural soil conditioner and fertiliser. Degradation to produce biogas represents 1-2% loss of weight. The resultant digestate represents around 25% of input and inert grit accounts for the remaining 9% of inputs. It is recognised that should the application to land outlet close, the digestate fraction may require landfilling as well. The grit may go to landfill or may have a market as a secondary aggregate.

In contrast, the first stage with a BMT is to dry the incoming mixed residual waste using the innate heat of the biodegradable material, involving drum systems, autoclaves or raised floors, leading to a moisture reduction of 20-25% or more. Subsequent sorting using magnets, eddy currents, air classifiers and manual picking can achieve further diversion of dry recyclables at 15-20%. The largest fraction (c.50% of the waste inputs, <20 mm by size fraction) is dry, odour-free with enhanced calorific value, at 12-16+ MJ/kg - more than twice the calorific value of unprocessed household waste and equivalent to wood or lignite, with coal being 27 MJ/kg. This 'fuel', probably in a pelletised form, can either be used for co-incineration in cement kilns or power stations - in particular displacing coal, or in petrochemical production (as a reducing agent) or for pyrolysis/gasification (see Annex 3). In the latter, a gas is synthesised from the hydrocarbon wastes from which methanol and/or hydrogen may alternatively be produced from the synthetic gas with markets as petrochemical or energy feedstocks.

It is likely, however, that cement kilns will target other high calorific and more homogeneous waste streams in preference to coal, rather than such fuel from residual municipal waste - depending on price, availability and consistency of quality and supply, and regulatory permissions (see Annex 4).

The EU Animal By-Products Regulation (EC 1774/2002), implemented in the UK with effect from May 2003 may provide further waste inputs for MBT/BMT if they are allowed to receive (and process by enclosed systems) wastes containing animal by-products and/or catering wastes.

With anaerobic digestion and pyrolysis/gasification regarded as 'advanced (thermal conversion) technologies', they qualify under the Renewables Obligation (RO), for the biodegradable fraction of waste inputs), in contrast to incineration which does not qualify. The RO requires licensed electricity suppliers to source a percentage of their sales from eligible renewable sources, starting at 3% and reaching 10.4% by 2010. Each MWh of renewable electricity generated is accompanied by a Renewables Obligation Certificate (ROC), which can be traded. One issue currently being discussed in this debate is the potential role of biomass fuels, with the very low proportion of forest cover (10%) being complemented by clean source-segregated secondary biomass waste, although problems posed by using such 'wastes' may deter co-firing markets.

Advocate General Jacob's opinion of October 2002 was confirmed by the European Court of Justice Court in February 2003, and accepted by the Commission in May 2003 : that incineration in municipal incinerators (the principal aim being incineration of mixed municipal wastes, with or without energy recovery) is disposal, but co-incineration of waste is recovery (e.g. in cement kilns or power stations where waste is used primarily to replace other fuels). This will impact on the Packaging Directive in the first instance, but also ELV and WEEE Directives. More fundamentally the decision will impact on the development of waste policy since it alters the interpretation of the Waste Framework Directive itself, which underpins EU and national waste strategies.

The various 'back-end' technologies tend to be provided by third party specialist providers (see company descriptions :-

- in-vessel composting : e.g. Alpheco Composting, SES Ltd

- anaerobic digestion : e.g. farmatic biotech energy UK Ltd, Greenfinch Ltd Thames Waste Management's parent company, RWE Umwelt operates a 22,000 tonnes per annum plant in Munster Germany)

- pyrolysis and gasification : e.g. Compact Power at Avonmouth, Mitsui Babcock Energy Ltd., Thermoselect (several plants in Germany and Japan, 30 - 225,000 tonnes per annum)

There is growing interest in new-generation MBT/BMT plants in the UK, but at this stage there is limited data on operational mass balance parameters, environmental impacts and financial data applicable to the UK situation. Some limited examples are quoted in this Paper, and data for an 'idealised' MBT (complementing enhanced source separation schemes) are given in Appendix 6. The following table is an attempt to compare reported mass balances of four technologies, but should be treated with care.

**Table 2 : Mass Balances of MBT/BMT plants (figures in percentages as recovered)**

| | Shanks ITS/ Ecodeco | Fibrecycle | SWERF | WASTEC | HLC |
|---|---|---|---|---|---|
| Glass + stone | 9.5 (8) | 3.4 | 8.5 | | |
| *Glass* | | *3.2* | | *3.3* | |
| *Stone + grit* | | *0.2* | | | |
| Metals | 3.0 (5.5) | 3.6 | 3 | 4.3 | |
| *Ferrous* | *2.6* | *2.8* | | *3.8* | |
| *Non-ferrous* | *0.4* | *0.8* | | *0.5* | |
| Mixed plastics | | 7.2 | 1 | 3.6 | |

| | | | | | |
|---|---|---|---|---|---|
| 'Recyclable' | 12.5 (13.5) | 14.2 | 12.5 | 11.2 | 19 |
| 'Compostable' | 9.0 - 10.5 (8) | 12.8 | | 29.9 | 13 |
| Secondary fuel | 43.0 - 50.0 51.2 | | 50 | 42.5 | 28 |
| $H_2O + C_20$ | 21.5 - 25.0 | | | | 15 |
| Residual to landfill | 14.0 (17) | 20.0 | 10 | 13.0 | 25 |

Sources : company literature

Notes:

1. No consistent method of reporting mass balances (and recovery rates) is used by the companies.
2. Composition of waste inputs is important, but such data is limited. Assumptions based on an operational 'three-stream' system will differ from mixed waste inputs with only limited recycling.
3. Some 'recovery ' figures have been recalculated taking into accountquoted recovery efficiencies.
4. 'Compostable' may mean 'sanitised biowaste' straight to landfill or suited to anaerobic digestion.
5. Secondary fuel usually includes paper, cardboard, textiles, other cellulose fibres and plastic film.
6. Figures do not necessarily sum to 100, due to missing data and rounding.
7. Data is also lacking to input into Life Cycle Assessment models- both waste flows and emissions.
8. Figures in brackets for Shanks reflect UK waste composition.

Other suppliers use different methods of showing mass balances, e.g. WasteGen

| | Product | Residue | Moisture loss | Total |
|---|---|---|---|---|
| Recycled | 16.000 | 2,000 | | 18,000 |
| Composted | 27,000 | 8,000 | 29,000 | 64.000 |
| Fuel-energy | 100,000 | 18,000 | | 118,000 |

**Barriers**

Although used in Germany, Austria and Italy since the early 1990's, and with over 70 plants in Europe (quoted by Heerman 2002), there is very little commercial operational experience in the UK, with a number of plants under construction or planned. Of these, nearly all are based on overseas technologies and there are reported variations in waste composition in host countries compared to UK data - most noticeably with reference to various biodegradable fractions (more paper and card in the UK and less putrescibles). Other local circumstances may include climate differences and especially seasonal variations, which also affects waste composition and its moisture content - with extremes of 25 - 50%. Where the input waste is received in plastic bags, there will need to be a bag-splitter and most systems will not be able to accept bulky household waste which in any case is not suited to such treatment.

A major selling point is their flexibility in terms of modular construction, but this may be a disadvantage in terms of higher capital and operational costs for smaller plants. Capital costs for a 60,000 MBT/BMT are quoted as £100 per tonne, compared to £350 per tonne for a 100,000 tonne incinerator - but pyrolysis/gasification would add a further £80-120 per tonne. Greenpeace data (2003) for a 100,000 MBT plant plus AD suggest a capital cost figure of £30 million (see Appendix 6). Quoted costs usually exclude land costs. In general, capital costs and related gate fees are 3-4 times that of landfill.

Costs depend on site (including planning approvals, emission limits and controls, aesthetic requirements), local and regional issues (range of available waste management options) and ownership (risk sharing, expected rate of return).

Operating costs, again excluding pyrolysis/gasification and also collection costs, are quoted as £40 – 70+ per tonne compared to £40-60 for incinerators in the UK and £80-100 for incinerators in the Netherlands (with tighter emission controls). Greenpeace data quotes £51-60 per tonne, depending on revenue from products - something which is a key variable, since markets are still to be developed for the different (lower quality?) reclaimed fractions. A recent article on the Wastec technology (March 2003) quotes '…operational costs from as little as £10 per tonne'. Operating costs for the Alpheco in-vessel composting are quoted at £10 per tonne (April 2003). Detailed breakdowns of these figures are difficult to obtain.

All waste treatments generate emissions and both MBT and BMT require sophisticated (and expensive) emission-control systems using bio-filters, thermal or catalytic combustion to meet tighter regulatory standards and minimise emissions to atmosphere. The HLC plant in South Wales (£30 million, with a capacity of 170,000 under a 25-year contract) received a Pollution Prevention and Control permit from the Environment Agency in May 2002. In May 2003, however, the plant was issued with an enforcement notice concerning the absence of monitoring equipment on the building's two extraction vents. The plant uses conventional combustion grate technology, with densified RDF/SRF pellets as inputs. A fire in the bio-filter unit of the 'composting' system in September 2003 means the plant will probably be out of operation for six months.

Further problems occur in translating batch process operations for pyrolysis/gasification to continuous methods. Given the relatively small scale of such plants, they may best be suited for dealing with more homogeneous high calorific hazardous wastes.

Operational processes with MBT result in 'stabilised waste', and it is doubtful whether this would qualify towards statutory Local Authority BVPIs. The Environment Agency regarded the output from the Dano Drum system in Manchester in 2001 (see Annexes 1 and 2) as stabilised waste rather than a product. EU proposals on biowaste in 2001 (European Commission *Working Document Biological Treatment of Biowaste, 2nd draft, February 2001*) referred to mechanical/biological treatment as:-

> 'treatment of residual municipal waste, unsorted waste or any other waste unfit for composting or anaerobic digestion in order to stabilise and reduce the volume of the waste'.

The same document defined compost, and provided guidance criteria for meeting the various definitions :-

> 'Compost' means the stable sanitised waste and humus-like material rich in organic matter and free from offensive odours resulting from the composting process of separately collected biowaste, which complies with the environmental quality classes of Annex III.
>
> 'Stabilised biowaste' means the waste resulting from the mechanical/biological treatment of unsorted waste or residual municipal waste as well as any other treated biowaste which does not comply with the environmental quality classes 1 or 2 of Annex III.

**Table 3 : Proposed criteria for EU Biowaste quality classes**

| | Source segregated[1] | municipal[1] Waste | compost[2] 1 | 2 | stabilised waste[2] |
|---|---|---|---|---|---|
| Lead | 73 (39 – 100) | 450 | 100 | 150 | 500 |
| Copper | 32 (24 – 39) | 120 | 100 | 150 | 600 |
| Nickel | 9 (3 – 12) | 45 | 50 | 75 | 150 |
| Zinc | 149 (98 – 179) | 600 | 200 | 400 | 1,500 |
| Chromium | 20 (5 – 36) | 120 | 100 | 150 | 600 |
| Cadmium | 1 (0.3 - <2) | 2 | 0.7 | 1.5 | 5 |

1. Dutch data from De Koning J, and van der Graaf J. H., J. M. Kitchen Food waste Disposers – Effects on Sewer System and waste Water Treatment

2. Compost and stabilised waste classes from EU Working Document Biological Treatment of Biowaste, 2nd Draft, 2001.

A further table was published in the December 2003 *Discussion Working Document on Sludge and Biowaste*, with figures again in mg/kg dry matter :-.

**Table 4 : Heavy Metals in Biowaste**

| | Mixed MSW 'compost' | Median biowaste compost | 90th Percentile compost | Sewage sludge |
|---|---|---|---|---|
| Lead | 181-720 | 63 | 105 | 104 |
| Copper | 114-522 | 47 | 80 | 330 |
| Nickel | 30-149 | 17 | 30 | 36 |
| Zinc | 283-1,570 | 181 | 284 | 811 |
| Chromium | 70-209 | 21 | 37 | 73 |
| Cadmium | 1.7-5.0 | 0.46 | 0.89 | 2.0 |

Sources : Table from *EU Draft Discussion Document on Biowastes and Sludges, December 2003*

1. Sewage sludge figures provided by Member States for 1999, and are weighted averages.
2. The 'compost' and compost figures are from Amlinger F. Pollack M. and Favoino E (2003) Heavy metals and organic pollutants from wastes used as organic fertilisers. Draft Final Report to DG Environment (unpublished).

It is probable that contamination of residual waste with household batteries and other household hazardous wastes will contribute to higher values, in comparison to source-segregated garden waste, and outputs will remain waste

A further table was published in *Resource, January/February 2004,* again emphasising the importance of source segregation – an illustrating the target levels laid down in *PAS 100 Specification for composted materials* 2002, published by the Waste and Resources Action Programme (WRAP) The Composting Association and BSI.

**Table 5 : Heavy Metal Content of 'Composts' from Different Sources**

| | Green Waste | Biowaste (green+food+ other organics) | Domestic Refuse | PAS 100 |
|---|---|---|---|---|
| Lead | 121 | 87 | 513 | 200 |
| Copper | 33.1 | 47 | 274 | 200 |
| Nickel | 9.7 | 22 | 45 | 50 |
| Zinc | 182 | 290 | 1,510 | 400 |
| Chromium | 10.6 | 49 | 71 | 100 |
| Cadmium | 0.44 | 1.0 | 5.5 | 1.5 |

| | | | | |
|---|---|---|---|---|
| Mercury | 0.22 | 0.4 | 2.4 | 1 |

Adapted from Funke (1992). *Guidelines for the composting of organic waste*.

Note the elevated levels all heavy metals except lead in biowaste containing food wastes, and the very much elevated levels of all heavy metals in mixed domestic wastes.

As mentioned earlier, another issue is how far such treated and stabilised waste will contribute towards meeting the Landfill Directive requirements for diverting biodegradable wastes from landfill. Reference has been made earlier in the Paper to the limit value of 5% Total Organic Carbon, and some technologies may not be able to meet this target for stabilised waste to landfill.

As at November 2003 DEFRA are considering the role of anaerobic digestion in contributing towards recycling/composting targets, with a Consultation Paper published by Defra.

The Waste and Emission Trading Act (November 2003) defines biodegradable waste as:-

> '… any waste that is capable of undergoing anaerobic or aerobic decomposition such as food and garden waste and paper and cardboard'.

Some concern has been raised with this 'absolute' definition in that it potentially favours thermal treatment, and excludes various technologies involving accelerated decomposition such as anaerobic digestion and MBT/BMT - which produce a relatively stable reduced residue. At Report Stage in July 2003 an amendment was proposed to the Waste and Emissions Trading Bill (see Annex 7), but subsequently defeated before the Bill received Royal assent in November 2003:-

> In determining whether waste is biodegradable for the purpose of the Bill the following is to be excluded :-
>
> (a) waste that has its biological activity significantly reduced through in-vessel accelerated aerobic or anaerobic decomposition from which emissions have been contained ; and
>
> (b) is within statutory limits of biological activity that the Secretary of State may specify by regulations

With existing kerbside and bank schemes capturing the higher quality dry recyclables, those processed through MBT/BMT may be of second grade, with fewer markets and lower prices. Problems have already been highlighted with reference to paper as a waste or resource (EN 643 - see Annex 5 - with mills proposing to accept only source-segregated paper). In addition, with further decline in UK manufacturing capacity the only markets may lie in Pacific Rim countries - providing part of a global solution to economic development, but not fitting with the self-sufficiency and proximity principles for dealing with waste in the UK.

The change in definition of recycling in the UK as mentioned earlier (January 2003), focussing on re-processing rather than 'sent for recycling', will also not allow moisture loss to count towards recycling. The change in the definition of mass burn incineration as disposal discussed earlier will also be of importance.

However, it is likely that producing a fuel is the most obvious output, but use in existing co-incineration or new pyrolysis/gasification plants is already leading to some NGOs and public opposition as 'incineration by another name' - especially if long distance movements are involved. Ironically some of these NGOs support landfilling in preference to the use of wastes as fuel. As at October 2003 it is unclear whether these processes will be acceptable as recovery or disposal, although the EU rulings are relevant to the discussion with reference to the principle objective of the process technology. In terminology, it is interesting that the terms 'Solid Recovered Fuel' (rather than Refuse Derived Fuel) and 'steam treatment' (rather than thermal treatment) are now being used in company literature.

**Discussion and Related Issues**

Although the emphasis in this Paper has been on new treatment/conversion technologies, some might say that it is yet another example of 'recycling' (in this case re-inventing wheels) with the Doncaster (30,000 tonnes) and Byker (50,000 later 85,000 tonnes) plants opened in 1979 being ahead of their time. These were crude 'MBT/BMT' type plants and both aimed at producing refuse derived fuel (RDF) as their main output. Doncaster tried to separate paper and plastics, Byker later separated aluminium and both tried to compost the fine material. Doncaster closed (after the abolition of Metropolitan Authorities) in March 1986, but Byker was still operating until 1999, supplying a municipal incinerator taking the Refuse Derived Fuel, when this ceased as a result of problems concerning the use of mixed incinerator bottom ash and air pollution control ash on allotments. In November 2003 the City Council agreed to pursue a waste management policy involving steep increases in recycling, with the Byker project unlikely to be revived. Newer RDF plants have been built on the Isle of Wight and at Pebsham.

Newer MBT/BMT systems involve higher quality 'stabilised waste' and/or RDF/SRF and less environmental impacts, together with greater reclamation/diversion efficiencies based on the back-end processes.

So far, few of the large waste management companies (Shanks and Biffa being exceptions) have entered the field in the UK, and this raises questions of investment priorities and preference for other waste treatment/disposal options. WRG are involved with mixed waste composting. An August 2003, Sita Environmental Trust published tenders to review technologies and processes and the potential role of UK policy and economic incentives, and a £239,000 study (funded through the Landfill Tax Credit Scheme) was awarded in February 2004 to Juniper Consultancy Services. The SWERF proposal for Canterbury includes partnership with Brett Waste Management, a long-established family business.

With barriers raised by waste management licensing (and IPPC regulations) and planning permission the issue of public acceptability will be very important. In Derby, initial optimism (and planning permission) for a SWERF plant dealing with residual wastes (220,000 tonnes per annum) has been met more recently by local opposition concerning emissions and potential health problems. Planning permission for the Shanks BMT plus waste to energy facility (to use the RDF) in Milton Keynes was rejected in October 2002, largely due to scale and proposed imports of residual wastes from outside Milton Keynes. In March 2003 Shanks submitted a revised proposal excluding the waste to energy facility, and in May 2003 there were delays in agreeing planning permission for the 4 x 60,000 tonne MBT plants, two associated MRFs and a green waste in-vessel composting facility – permission finally being granted in October 2003.

In contrast, in August 2003 Shanks East London was granted planning permission for a 4.2 ha ecodeco plant at Frog Island in Havering, with planning permission for the Jenkins Lane site in Newham granted in September 2003.

The attraction of MBT/BMT plants is the flexibility provided by their modular nature, where units can be added to cope with increased tonnages or 'mothballed' with increases in recycling /composting. In contrast, Sheffield is an example where its waste strategy, in partnership with Onyx, includes the construction of a replacement mass burn municipal incinerator (combined heat and power) with a capacity of 225,000 tonnes per annum within a 30-year contract, regarding by opponents as too inflexible and a disincentive to recycling.

On the other hand, North Somerset Council advertised in May 2003 seeking expressions of interest for a pilot gasification plant to accept municipal waste. At Wrexham, original proposals for a mass burn incinerator were to be discussed at a public enquiry in may 2003, but the company (HLC) submitted new plans for a pyrolysis/gasification facility instead. Proposals for Dumfries may involve planning permission for 90,000 tonnes, with perhaps 3 x 30,000 Compact Power plants.

In January 2004 the planning application for the proposed SWERF plant in Canterbury was withdrawn. With an initial capacity of 110,000 tonnes, rising to 165,000 tonnes, the application was withdrawn as Kent County Council announced a review of its waste local plan following a technical review of the application by a specially appointed panel. The council confirmed that the facility remains an option, and will be re-considered when the new Allington energy from waste plant (contract signed in March 2004) is operational.

London 'pioneered' a new approach earlier in 2003 with its 'pseudo invitation' to tender for new waste management technologies to meet the needs of a hypothetical London Borough and London as a whole - fully reported in the *City Solutions* report and web site referenced at the end of the Paper.

To put this issue into perspective, the Environment Agency expects at least 1,000 new waste management facilities will be required in order to meet the requirements of the Landfill Directive, and industry estimates that four new waste facilities will be needed for every landfill site that closes. A report by the Institution of Civil Engineers in June 2004 estimates that 1,500 – 2,300 new waste management facilities will be needed by 2020. This will place a strain on both the planning system and on environmental licensing processes, with bodies such as ESA arguing for 'type approval' mechanisms to be introduced in order to avoid repetitive and costly local applications. Co-location on existing sites for co-incineration in cement kilns or power stations or feedstock derivation for petrochemicals may offer suitable alternatives - especially where such sites are served by rail links and would benefit from economic and social regeneration (and possibly access to other funds for capital investment). Quotes in August 2003 suggest that public inquiries for municipal incinerators (the example quoted being Bexley in East Sussex) are costing at least £750,000, and involves debate concerning the role of central government and local government in explaining and educating the public about health and safety issues.

Most company proposals (those in the table earlier in the Paper) include a budget for education and publicity, recognising the importance of overcoming public opposition.

With reference to cement kilns, current controls are set out in the 'substitute fuels protocol' (SFP), issued by the Environment Agency in 1999, together with a simplified protocol for permitting of tyre burning trials published in 2001. The cement industry's commitment to diversifying fuel supply is critical in that the SFP requires two separate permit applications - one for trial burns, and the second to allow commercial combustion - when an operator initially proposes to burn waste, increase the maximum permitted fuel substitution rate, or add a new waste-based fuel. Three stages of public consultation are involved, with the full permitting process typically lasting 17-30 months and costing up to £600-800,000.

Since 2001 the use of liquid fuels and waste tyres has replaced about 6% of its fossil fuel consumption, and further data is shown in Appendix 4.

The Environment Agency has embarked on a two-stage overhaul of the SFP which should radically truncate the decision-making process. In May 2003 The SFP was amalgamated with they tyres protocol, bringing the former in line with latter's single permit. Further overhaul proposals were distributed in July 2003, potentially enabling the cement industry to increase its role in sustainable waste management:-

- covering the scrapping of minimum calorific values (currently 21 MJ/kg), reflecting EU proposals covering burning wastes and the definition of recovery and disposal. This might be replaced by an obligation to demonstrate that wastes have a sufficiently high calorific value to generate the 'required process temperature' in order for the operation to qualify as 'recovery'

- scrapping the ban on certain waste types, providing they meet the revised calorific value requirements. To include PCBs, waste streams from the manufacture of pharmaceuticals, pesticides and biocides. Radioactive wastes will continued to be banned

- with cumulative data on the use of substitute fuels, the Environment Agency is satisfied that in most cases the change would not be classed as 'substantial change' and can be determined outside the formal permitting process and hence avoiding public consultation

- the number of substances subject to emission monitoring during waste combustion trials will be reduced, based on evidence of only trace quantities being measured. Operators will, however, have to characterise emissions of volatile organic carbon and assess their environmental significance when a fuel mix is changed

These revised arrangements would take effect after the EU waste incineration Directive comes into force in December 2005, bringing the cement industry on the same footing as mass burn incinerators. The changes might allow more imports of wastes as fuel into the UK, and will impact on the UK high temperature incineration companies that take hydrocarbon-based liquid fuels. A second consultation paper was published in March 2004.

The Environment Agency is set to improve environmental controls on cement and lime kilns in England and Wales.

The Environment Agency believes the new measures will reinforce our framework for controlling the practice of substituting waste streams for fossil fuels, thereby providing robust protection of public health and the environment, but also enabling wider environmental benefits to be realised in the form of lower emissions of key air pollutants such as oxides of nitrogen (NOx) and reduction in the use of fossil fuels.

Substitution of fossil fuels with waste streams is a practice common across Europe and one which is increasingly being proposed by the cement and lime manufacturing industry in the UK. Substitute fuels currently in use, being trialled or proposed in England and Wales include tyres, liquid substitute fuels, sewage sludge and meat and bone meal.

In October 2004, new measures were put before the Environment Agency Board, and will require kiln operators to : -

- justify the environmental benefits of the waste streams they are increasingly seeking to substitute for conventional fossil fuels

- identify what is in the fuels they propose to burn, so that the environmental and health impacts can be considered and to prevent wastes which could more usefully be recycled or re-used being considered for fuels or elements of fuel blends

- document and make the information publicly available - engage in open consultation with local communities about proposals to burn substitute fuels and about any significant proposed changes to substitute fuel burning

- meet revised emissions monitoring and reporting requirements designed to reflect the materials in the fuel(s) being used

The new measures will be implemented by the Environment Agency through a revised version of its Substitute Fuels Protocol, which sets out the principles and procedures the Agency follows in handling all applications from cement and lime makers to burn substitute fuels. The revised Substitute Fuels Protocol will apply from 1 January 2005.

Revision of the Substitute Fuels Protocol is also consistent with new EU legislation (the Waste Incineration Directive) and European Court of Justice judgements.

Of potential relevance in terms of co-incineration in power stations is the report by the Institution of Civil Engineers published in July 2003, concerning electric power in the UK in 2020. This report suggests that by 2020 80% of electricity could be generated using imported gas from 'politically unstable countries thousands of miles away', compared to current overall gas use of 38% to generate electricity (mainly UK-based). IN March 2004 National Grid Transco pointed to a substantial shortage of gas deliveries by 2008. Many coal-fired power generating plants will close after 2016 due to emission constraints (currently supplying 32% of electricity) and only one nuclear power plant is expected to remain operational beyond 2020 (nuclear power currently supplies 23% of electricity).

In summer 2003, related issues and developments involving energy include : planning problems associated with on-shire wind farms, Friends of the Earth naming and shaming polluting coal-fired power stations, plans for a gasified coal-fuelled power plant in Doncaster, National Grid warnings (for the seventh time that summer) of insufficient capacity margin in the power market for England and Wales. At November 2003, some 40% of electricity generating capacity in the UK is in the hands of creditor banks. Electricity is a commodity, but cannot be stored.

The issue of power failures in the USA/Canada in mid-August 2003 and Italy in September 2003 have also been posed for the UK. In each case being linked to a change to a more liberalised power generating regime based on competition, lower consumer prices (wholesale prices in the UK have fallen by 40% since 1998), less surplus generating capacity and under-funded transmission capacity. Lower wholesale prices have meant lower prices for consumers, but accompanied by price fluctuations have deterred new infrastructure investment.

The localised power failure in south London in September 2003 reinforced this issue. In October 2003 International Power re-instated the 500 MW gas-fired station on Deeside and Powergen also announced that it would consider re-instating its oil-fired 650 MW station on the Isle of Grain. Similar announcements by other companies mean that the ‘safety margin’ in the UK has improved to 19-20%, in contrast to 17.7% in 2002 and fears that it could fall to 7% with extreme winter weather.

A new £500 million programme was announced by Ofgem in March 2005 for power-distribution companies to invest in renewables, especially with reference to the electricity distribution network for connecting green energy to the national grid. This could be of relevance for waste to energy plants.

Further difficulties may lie ahead with the Large Combustion Plant Directive and targets to reduce sulphur dioxide emissions by 575,000 tonnes per annum. This may lead to more use of imported coal with a lower sulphur content, with issues of cost and long term security of supplies. In addition power generators in March 2004 expressed concern that $CO_2$ targets (a reduction of 16.3%) could lead to a shortfall of 35-40 million MWh out of a UK total of 2 340 million MWh.

A report by Fichtner Consulting Engineers in June 2004 on the use of RDF suggested that such market opportunities may be more limited. In estimating a total of 3.4 million tonnes of RDF supply by 2013, the report concluded :-

- the cement industry, which enjoys a concession under the Waste Incineration Directive enabling it to accept a wide variety of waste derived fuels, would place RDF relatively low on its suitability ranking. The estimated capacity for RDF would be c. 350,000 tonnes

- due to the co-incineration requirements which apply to coal-fired power stations under the Waste Incineration Directive, ether is almost no prospect of a UK coal-fired power station using RDF as a substitute fuel until 20106, when any plants remaining in operation would have to be capable of achieving the co-incineration emission limits for NOx. Many of these power stations may have closed by 2016.

- the paper industry might offer an alternative market for RDF through dedicated (high calorific value) RDF power stations mixed with (low calorific value) de-inking sludges. Demand could be up to 500,000 tonnes.

- the steel industry uses pyrolysis in coking ovens, prepared coke is mixed with iron ore in the blast furnace and coal is injected into the blast furnace to provide additional heat. Whilst syngas and substitute fuels might be considered, quality controls, surplus gas on site and possible problems in being classified as co-incineration make this an unlikely potential user of RDF.

Not all the new technologies have been successful in converting the end-product into a viable energy supply. In July 2003 Energy Developments (EDL) in Australia - the company behind the SWERF process in Australia, partnered by Texas group Brightstar Synfuels, announced that it was to write-off up to $98 million.

A problem in evaluating the relative performance of MBT/BMT technologies is that the Environment Agency WISARD life-cycle assessment software for municipal waste management, designed to help Local Authorities identify the Best Practicable Environment Option, excludes them due to lack of data. Interim practice is to use surrogate datasets but their reliability is subject to challenge and the Agency is currently letting a contract to revise and update the datasets. A new research contract to update the WISARD tool was signed in October 2003.

There will also be the need to look beyond statutory Local Authority BVPIs for 2003/04 and 2005/06. New (draft) EU packaging targets have to be met by December 2006 (a maximum recovery target 60%, an overall recycling target of 55%, with material specific recycling targets for glass at 60%, paper and board 60%, metals 50%, plastics 22.5% and wood 15%). Landfill Directives diversion targets for treating biodegradable municipal waste by 2010 (to 75% of 1995 levels, 2013 (50%) and 2020 (35%), and UK aspirational recovery/recycling targets for 2010 (45%/30%) and 2015 (67%/33%). Problems posed by animal by-products are leading to more enclosed composting operations, with the implementation of EU Regulations with effect from May 2003, and a move away from open windrow.

It is likely that kerbside collections of dry recyclables and/or organic waste will increase. Proposals to extend kerbside recycling include the draft Kerbside Recycling Bill introduced in late 2002**,** renamed the Municipal Waste Recycling Bill with effect from March 2003, backed by the Government as the Household Waste Recycling Bill in June 2003, and receiving Royal Assent in October 2003. The Bill originally proposed a new household recycling/composting target of 50% for 2010, but this has been replaced by a requirement that all English Waste Collection Authorities provide kerbside collection schemes to all households covering at least two types of recyclable or compostable waste - reinforcing the 'three-stream' approach mentioned earlier This would be done by amending Section 45 of the 1990 Environmental Protection Act which places a duty on Local Authorities to collect household waste. An Authority would be excused if the cost of providing the service was 'unreasonably high' or 'comparable alternative arrangements' were available - such as drop-off/bring banks within 100 metres. The Secretary of State is to report to Parliament by October 2004 on progress by each Local Authority.

One major problem is how to increase participation rates and capture rates in order to meet much higher recycling targets than the 12% in 2000/01. Behaviour change is more fundamental than merely providing kerbside collections.

**Table 6 : Participation, Recognition/Capture and Diversion/Recycling**

| Participation Rate (%) | Recognition/Capture Rate (%) | 'Diversion/Recycling' Rate (%) |
|---|---|---|
| 90 | 90 | 81 |
| 80 | 80 | 64 |
| 70 | 70 | 49 |
| 60 | 60 | 36 |
| 50 | 24 | 12 |

The diversion/recycling rate is 'as collected' and excludes any residues at a MRF or re-processing plant or MBT/BMT plant. A criticism of MBT/BMT is that such technologies might work against such source segregation, and thus not meet the treatment requirements of the Landfill Directive.

In addition to promoting 'consumer responsibility', another major problem is how to finance such expansion in kerbside recycling, and ultimately who pays ? There is limited information available yet in the UK to evaluate long term performance of such technologies, vital if operational risks are to be quantified and supplying information to encourage relevant investment.

The question of differential and variable charging for the collection of household recyclables/compostables and residual waste will have to be addressed sooner rather than later.

In addition, the modular nature and mix of technologies with MBT/BMT does, however, offer the opportunity to respond to changing waste composition, increased recycling/composting through source segregation and the need to see wastes as resources. Evidence from a recent Green Alliance Report suggests that in the Netherlands, 70% participation rates in kerbside schemes and an overall household recycling rate of 40-45% appear to be the maximum rates achievable (excluding any contributions from MBT/BMT). This leaves 55-60% of waste for incineration (and/or co-incineration) or landfill.

More transparent information is needed on capital and operating costs and likely gate fees, especially in the context of increases in landfill tax with effect from April 2005 to £18 per tonne (an increase of £3 from 2004) leading to £35 per tonne in the medium/long term - compared to £14 per tonne with effect from April 2003 and £15 with effect from April 2004.

Developing alternative 'products' from the dry BMT fraction may offer a more acceptable alternative to energy recovery. For example, current development work by at least one company includes developing potential markets in composite tile products, fibre board, insulation board, door and wall panelling and roof tiles, and looking at anaerobic digestion rather than pyrolysis/gasification.

In terms of their role in broader issues of greenhouse gases and environmental pollution, putting stabilised waste into landfill will involved reduced leachate and methane emissions and the higher density of the material will save on void space.

As with all waste management activities there will be health and safety issues to be managed, and MBT plants may fall into the same category as composting with plants having to be at least 250 metres from housing and businesses. In all types of composting, key issues are stabilisation (the end of the process during which bacteria consume and break down nutrients in the raw material generating heat) and sanitisation (the process of destruction of harmful organisms, usually referred to as pathogens). Both are easier to control with centralised composting (windrow and in-vessel) or other organic treatments such as anaerobic digestion. A 'dirty' MRF will present health problems for workers, residuals from MBT/BMT will need to be disposed of in terms of public health and environmental protection objectives. Inert residuals for landfill may be 5-20% of inputs (quoted by suppliers), but emission-control residues may be more hazardous - hence the focus on (expensive) bio-filter or catalytic filter systems.

As mentioned earlier, MBT or BMT, therefore present a range of both commercial risks and political risks - compounded by potential liability claims for environmental and/or health impacts and higher insurance premiums. Some writers argue that investment in such technologies would remove the incentive for source segregation in kerbside and/or bank schemes, with a focus on dealing with larger waste volumes rather than residual waste from a three-stream system.

Work by Dominic Hogg using Life Cycle Assessment, and reports by Greenpeace have shown that bespoke packages of MBT can offer significant environmental advantages compared to landfill and incineration in terms of climate change, acidification, eutrophication and human toxicity, although some would call these claims visionary.

All forms of waste management will cost more in the future in order to meet EU and UK legislative targets and with higher landfill tax rates likely to be used as a key fiscal driver. MBT/BMT pre-treatment will cost more than traditional landfill, but it may offer the modularity/flexibility not available with large mass burn incinerators, especially if alternative 'products' can be developed from the various residual waste fractions, as well as (or instead of) the production of RED/ERF.

Although not the main focus of this Paper, other more advanced conversion technologies are also being developed and may offer alternatives in the future for dealing with specific waste streams. A Texan company (Cyntech Technologies) has developed a process which they claim will convert 10,000 used tyres into diesel every day, and will also process mixed plastics and carpet fibres into diesel fuel, liquefied petroleum gas and synthetic gas. Another experimental US technology ('thermal depolymerisation process - TDP) has been running in Philadelphia since 1999, turning turkey processing waste into gas and oil (Changing World Technologies). A third technology, related to welding, is plasma arc, an electric arc in an oxygen-starved furnace operating at 3,000 - $10{,}000^0$C. The outputs are a hydrogen-rich gas (primarily from organic wastes) plus leach-resistant vitreous residues and an overall 90% reduction in volume with no ash products. This process also has the potential to provide a 'safer' method for dealing with a range of hazardous wastes, especially important with the reduction in capacity of high-temperature incinerators and hazardous waste landfill sites in the UK. The process is, however, a net consumer of electricity.

In contrast, the Direct Melting System for MSW Recycling developed in Japan by Nippon Steel since 1979 has over 20 plants in operation or under development. These take a range of waste streams, have very low emission problems, recover heat and generate a range of useful resources as outputs.

At the other end of the scale :-

- Estech Europe have developed a Mobile Demonstration Plant (MDP), constructed on three trailers and capable of handling 5,000 tonnes per annum.

- Jarshire has developed a self-powered multi-material waste management mobile MRF, housed in a transportable customised container up to 40 feet long

**Conclusions**

This Paper has reviewed the emergence of MBT/BMT technology systems in the UK over the last few years, and a number of key issues have been identified :-

- the overall strategic aim of waste policy is to move towards sustainable and integrated waste management with wastes being recognised wherever possible as resources
- this aim is underpinned by a series of legislative and fiscal drivers to promote the waste hierarchy, including recycling and composting, and thus raising the whole question of sustainable resource use and the use of wastes as secondary raw materials
- despite the medium/long term vision of 'zero waste', increased recycling and composting targets will leave a significant tonnage of residual waste to be managed
- MBT/BMT offer new technology systems to compete with incineration and landfill, with potential 'pick and mix' solutions at various scales to meet local circumstances
- some these are alternatives to 'tried and tested' energy-from-waste plants, currently facing public opposition in the UK
- a range of legislative, regulatory and fiscal measures – most notably including definition issues - are in place but these have yet to be fully applied and tested with reference to MBT/BMT in the UK
- there is an urgent need for more data on waste inputs (and impact of variations in waste composition), process mass balances, long term reliability, the nature and valorisation of outputs, emissions to the environment and issues of health and safety and costs
- ultimately, the public will be expected to pay more to meet the laudable aim of sustainable and integrated waste management, but delivery will depend on the balance between the private sector (and commercial risks) and the public sector in delivering step changes in waste management behaviour and accepting new technologies in 'their back yard'
- land use planning issues will remain a problem until a revised PPG 10 is published, unless type-approval permission are out in place and waste management strategies include definitive site locations as well as policies

Finally, there are the dynamics affecting waste management : growth in waste arisings (and/or de-coupling waste from economic growth and consumer expenditure), changes in waste composition, changing legislation (including waste Directives and producer responsibility, and driven especially by the EU 6$^{th}$ Environmental Action Programme), higher landfill taxes, differential/variable charging for household waste, possible taxes on incineration, tradable landfill allowances, technology innovation/transfer and markets for MBT/BMT 'products' in contrast to 'fuels'.

With progress towards producing a draft Directive covering revision of the Sewage Sludge Directive (86/278/EEC) and the biological treatment of biodegradable waste, in December 2003 the EU Commission published a *Discussion Working Document on Sludge and Biowaste*. This discusses a range of issues concerning management of these wastes (landfilling, incineration), the positive aspects of sludge and biowaste to soils (organic matter, fertilisation properties, alternatives to peat, green energy and organic matter recycling, carbon sink and the greenhouse effect) and potential environmental problems (nutrients, heavy metals, organic compounds, pathogens).

This Discussion Working Document was distributed in the context of a proposed Biowaste Directive :

> ‘ to establish rules on the safe use, recovery, recycling and disposal of biowaste, to control potential land contamination and to encourage the use of certified compost. The Directive will focus on biodegradable municipal waste (BMW) and complements the BMW diversion targets of the Landfill Directive’

A number of proposals are relevant in the context of MBT :-

- MBT may play an important role as a complementary treatment option along the lines of the provisions of the Landfill Directive, which requires a pre-treatment of the waste to be landfilled to achieve further reduction of its biodegradability. It may also be well integrated with energy recovery from residual waste, whose pre-treatment may improve conditions for thermal treatment, giving the system the needed flexibility to cope with the variations of calorific value as a consequence of progressive growth of the biological treatment of biowaste. It would be important to define conditions for the MBT process and rules relative to the use of MBT residues. The objectives could be to clearly distinguish MBT residues from high-quality compost. At the same time, MBT process parameters could be optimised in order to reduce the biodegradabilty of MBT residues in case of landfilling. These points are covered in Annex II on Biowaste :-

- provisions should provide for minimum process requirements (residence time, temperature, environmental conditions, etc) for anaerobic digestion, composting and mechanical/biological treatment (MBT) in order to ensure that the best techniques and standards are applied. This would be a crucial point in terms of market possibility for compost and of possible destinations for stabilised biowaste. Sanitisation requirements with respect to animal and human welfare should be introduced and sanitisation requirements for plant protection could be considered.

- it could be envisaged to consider that separately collected biowaste being subject to a defined composting process resulting in the production of a high quality compost meeting specified quality standards has undergone a recovery process in the sense of operation R3 (‘Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes)’) in Annex IIB to Directive 75/442/EEC as amended by Directive 91/156/EEC (The Waste Framework Directive. *WRAP and BSI have progressed in this area with the publication of PAS 100 Specification for Composted Materials in October 2002.*

- The use of digestion residues from anaerobic digestion should be subject to Directive 75/442/EEEC as amended by 91/156/EEC and to a monitoring system equivalent to the one in force for sewage sludge in the case of landspreading, unless they are composted.

- The production of energy from the combustion of biogas produced with the anaerobic digestion of biowaste is classified as renewable energy in accordance with Directive 2001/77/EC. As anaerobic digestion also results in the production of a solid residue (digestate) that can be composted and used on land, it may be considered as a combination of energy recovery and material recycling, the elaboration of harmonised guidelines for determining which share of the incoming biowaste has been energetically recovered and which has been recycled could be envisaged. *Defra published a Consultation on the role of anaerobic digestion of municipal waste within the Best Value Performance Standards in October 2003:-*

*'Composted' means the controlled biological decomposition and stabilisation of organic substrates,* ***either*** *under conditions that are predominantly aerobic and that allow the development of thermophilic temperatures as a result of biologically produced heat* ***or under circumstances that are predominantly anaerobic in a biogas plant****. It results in a final product that has been sanitised and stabilised, is high in humic substances and can be used as a soil improver, as an ingredient in growing media, or blended to produce a top soil that will meet British Standard BS 3882, incorporating amendment No. 1,* ***or applied to the soil as a liquid fertiliser****.* In *the case of vermicomposting these thermophilic temperatures can be foregone at the point the worms are introduced.*

- the land spreading of stabilised biowaste produced from mechanical/biological treatment (MBT) of mixed MSW or residual waste can potentially present the same problems and opportunities of the landspreading of sewage sludge. In the long run, it can hardly be subject to any improvement of quality, as contamination does not come primarily from point sources as in the case of sludge. To avoid any confusion with compost produced from separately collected waste, the reside from MBT should not be called "compost". Its application should be restricted only to land where food and feed crops are not cultivated, e.g. for landscaping purposes.

- it could be envisaged introducing certain technical specification for MBT-treated biowaste to be landfilled, in such a way that stabilised biowaste would not be considered actively biodegradable an more. When these conditions, which should refer to residual fermentability, are fulfilled, the landfilling of such MBT-treated biowaste should not count against the targets of Article 5 of the Landfill Directive 1999/31/EC.

- Unless already required under the IPPC Directive 96/61/EC, biological treatment plants should have a permit which would provide for some basic guarantees such as health and safety requirements for workers, treatment of leachates, lining under the compost heap to protect groundwater, odour control and minimum distances from buildings (unless capacity and materials suggest otherwise, e.g. for small scale composting plants of garden waste.

- Along with classification parameters, labelling requirements could be needed in order to inform end users of the feedstock material (separately collected biodegradable waste, garden waste, organic fraction from unsorted MSW, sewage sludge, green waste), of the characteristics of the product (organic matter, pH, salinity, pollutants), of its correct use (spoil improver, growing media, mulch), of its rate of application (to take account of the nutrient load).

- Such Community-wide quality requirements are important in terms of the functioning of the internal market, avoiding obstacles to trade and distortion and restriction of competition, and prevention of 'eco-dumping' of poor quality materials (stabilised waste rather than compost) from biowaste processing.

In June 2004 the European Commission announced that it was not going forward with a separate Biowaste Directive, but now plans to include it in a revised Thematic Strategy for Soils. This decision potentially delays agreement on important criteria for different grades of 'compost', including that from MBT and similar plants.

In developing the Waste Implementation Programme to 'deliver' the government's waste strategy, Defra announced in May 2003 that Work Stream Three - New Technologies Programme would address some of the issues raised in this Paper. The aim is to overcome barriers within the UK market to the successful development and take-up of waste management technologies in England. It is hoped that the programme will be fully launched in autumn 2003 following state aids clearance for the proposed funding programmes. The programme will address the barriers to implementing both near-market (proven technically, but not financially proven) and proven technologies (proven both technically and financially). £3.5 million allocated to Winter 2003. There are four objectives :-

- **Waste Research and Innovation Programme** : now called the **Technologies & Research Innovation Fund (TRIF)** for R&D projects involving new technologies, aiming to lead the development of cleaner, faster, cheaper and acceptable ways of treating wastes. £2 million.

  The first round of projects to be funded was announced in October 2004 :-

  Project 1. University of Leeds, Evaluating the effect of autoclaving on the rate of bioprocessing of waste

  Project 2. C-Tech Innovation Ltd, Biological hydrogen production from domestic wastes and increased biodegradability

  Project 3. Imperial College London, Anaerobic membrane bioreactor technology for biodegradable waste stabilisation.

  Project 4. University of Southampton, Particle Size requirements for effective bioprocesessing of biodegradable municipal waste

  Project 5. University of Nottingham, Developing high power microwave processing as an effective technology for the thermochemical conversion of biodegradable municipal waste

- **Demonstrator Programme** : a funding programme to help establish commercially viable waste treatment technologies, reduce perceived risks of implementation and provide accurate data on technical and economic performance. £30 million, in 2 tranches with 5 plants in operation by December 2005 and 5 initiated/in operation by December 2006. Managed by RPS Limited.

  In September 2004 the list of 'Preferred Bidders' for the Demonstrator Programme Round 1 were announced :-

  - **WasteGen UK Ltd** (pyrolysis and probably gasification using German technology from Tech Trade), 60-70,000 plant residual municipal waste from Corby District Council) on a site in Corby owned by Anglian Water

  - **Devon County Council** (pyrolysis and/or gasification using Compact Power technology, based at Avonmouth), in conjunction with Viridor Waste Management and Exeter City Council, to process 30,000 tonnes per annum located at a waste transfer station in Exeter

  - **Premier Waste Management Ltd** (MBT/in-vessel aerobic composting), scaling up a 5,000 tonnes pilot plant to process 40,000 tonnes at Thornley in County Durham

  - **Greenfinch Ltd** (anaerobic digestion), in conjunction with South Shropshire District Council on site in Ludlow, processing 5,000 tonnes of source-segregated garden and kitchen waste (a small scale pilot plant handling 1,500 tonnes operated at the site between 1999 and 2001)

  - **Golder Associates** (MBT + anaerobic digestion + composting, based around Belgian technology firm Organic Waste Systems) at Sita's landfill site at Packington near Birmingham

  - **ADAS Consulting** (MBT + batch tunnel composting using GiCom technology), on a site near St. Ives in Cambridgeshire leased from former mushroom composting company Hensby Compost

  - **Fairport Engineering** (material separation/complex material recycling facility/gasification, base on history of supplying process equipment to various sectors), 40,000 tonne plant to produce refuse derived fuel pellets for the cement, power generation and gasification industries. To be located in North West England

- **Waste technology support** : impartial advice and support to Local Authorities and the Waste Management Industry, aiming to increase existing knowledge and understanding of new technology and motivate the sector to make the necessary behavioural change. £4 million delivered via Enviros, See *Defra Waste Implementation Programme New Technologies (2004). Introductory Guide : Options for the diversion of Biodegradable Municipal Waste from Landfill. Prepared by Enviros Consulting Limited.* Contact wastetech@enviros.com

- **Waste technology data centre** : a joint project with the Environment Agency to develop a website resource of up-to-date information on waste treatment technologies in the UK and abroad, and impartial advice on regulation, authorisation, performance and costs. See Waste Technology Data Centre under 'contacts' and www.defra.gov.uk/environment/waste/wip/newtech/index.htm and www.environment-agency.gov.uk/wtd

This website will cover composting, mechanical biological treatment, anaerobic digestion and advanced thermal treatments such as pyrolysis and gasification. For each technology the following information will be collated in a consistent and comparable format :-

- site information and scale of operation
- types of waste feedstock
- costs and other information
- mass balance
- regulatory issues
- environmental/public health issues

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E&OE.

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**Contact details**

As part of the Waste Implementation Programme Workstream Three : New Technologies, The Environment Agency is compiling a list of technologies with key summary characteristics and data. See Waste Technology Data Centre www.defra.gov.uk/environment/waste/wip/newtech/index.htm

The technologies featured will include composting, MBT, anaerobic digestion and advanced thermal treatments such as pyrolysis and gasification. The type of information available on each technology will be :-

- site information and scale of operation
- types of waste feedstock
- costs and other information
- mass balance
- regulatory issues
- environmental/public health issues

The website went 'live' in June 2004, with an initial 30 case studies – increasing to 60 by April 2005 plus all the New Technologies Demonstrator Programme projects.

Also see Fichtner Consulting Engineers Limited (2004). *The Viability of Advanced Thermal Treatment of MSW in the UK*, which has been used to provide some of the following information.

*(The descriptions for various technologies/suppliers are summarised from company literature, mainly in the context of the UK and the list and descriptions are not comprehensive)*

AGRIVERT mail@agrivert.co.uk
*(takes unsorted MSW and initial grinding is followed by metal separation and screening of fraction for landfill or energy recovery. Tunnel composting is then followed by screening, further fraction for landfill or energy recovery, refining plus access of mineral and organic fractions plus mineral/aggregate recovery).*

Alpheco containerised composting systems. info@alpheco.co.uk www.alpheco.co.uk
*(provider of in-vessel composting systems).*

Brightstar (Wollongong in Australia, Derby and Canterbury). www.brightstarenvironmental.com
*(the SWERF technology involves pre-processing of MSW in autoclave(s), followed by materials separation using trommels, magnets and eddy current separators with the pulp washed and dried, followed by thermal conversion using gasification. Single reference plant in Australia operating intermittently at 25,000 tonnes per annum, rather than design capacity of 100,000)..*

Central Bottling International, Doncaster. www.centralbottling.com
*(aerobic process for source segregated organic wastes. Visual check on input conveyor to remove contaminants then fully automated. Material is macerated twice then aerobically treated in a series of temperature controlled tanks. End product is pasteurised and safe for animal feed or land application).*

Compact Power. Info@compactpower.co.uk www.compactpower.co.uk
*(operates a combined gasification and pyrolysis plant under a IPPC permit for a number of waste types. Plant in Avonmouth has a capacity of 8,000 tonnes per annum. In summer 2003 in discussion with various potential clients - Local Authorities and for special wastes. Recent collaboration with HLC EnvironmentalProjects. Signed a five-year alliance with international project management company, AMEC to roll out development of its pyrolysis and gasification system – a full size plant will be able to process 32,000 tonnes of waste or biomass per year in a modular system, with electricity generation qualifying for ROCs).*

Cyntech Technologies.
*(a process which they claim will convert 10,000 used tyres into diesel every day, and will also process mixed plastics and carpet fibres into diesel fuel, liquefied petroleum gas and synthetic gas).*

DRANCO (DRy ANaerobic Composting), operated by Organic Waste Systems (OWS) in Belgium
Mail@ows.be www.ows.be
*(thermophilic or mesophylic one-phase anaerobic fermentation system with high biogas yield).*

EBARA Corporation, Switzerland

Ecobond Limited Ltd www.ecobond-international.co.uk
*(Wastefile UK + Advance Enterprises combined in 2002 to offer ACR, a water-based chemically engineered hybrid polymer emulsion process converting waste materials into composite products)*

Energos
*(pre-shredding, static grate gasifier with combustible chamber directly above the grate +_ steam generation. 5 plants operating in Norway and 1 in Germany, with each module processing 35,000 tonnes per annum)*

Enerkem/Novera
*Feedstock reception, pelletisation, storage + gasification in bubbling fluidised bed. Marketed for high calorific value plastics and RDF. Reference plant in Spain.)*

Entsorga www.entsorga.it

Fairport Engineering Limited www.fairport.co.uk
*(depending on waste inputs, recovering recyclables and biomass fuel products. Biomass fuel for industrial boilers, cement kilns, power generation, small-scale gasification or lightweight aggregates. Pilot plant in Lancashire, financial support from DTI, looked at quality of biomass fuel).*

farmatic biotech energy UK Ltd. Holsworthy Biogas Plant. www.farmatic.com (go to English version).
*(the first large-scale AD plant in the UK at Holsworthy in Devon, 146,000 tonnes per annum of food wastes plus animal by-products plus agricultural manure).*

FERCO
*(fuel drying + gasification in circulating fluidised bed. Single demonstration plant in Virginia (USA) has tested RDF but MSW only tested in a small pilot plant).*

Fibrecycle the 4$^{th}$ Generation. Waste Cleansing Reduction & Recycling Ltd., Northgate, Aldridge, West Midlands, WS9 8TY. mail@estecheurope.com
*(infeed conveyor to autoclave(s) supported by steam accumulator and condenser, debris roll screen with fines via air classifier to fibre output, overband magnet and eddy current separator plus plastic sorting. Estech is UK sole agent for the Portagester Technology for Anaerobic Digestion).*

*(a new Mobile Demonstration Plant consists of three components : the MSW Fibrecycle process (autoclave, accumulator and condenser), materials recovery (debris roll screen/air classifier, overband magnet, eddy current separator, recovery facilities) and power plant (50kVA diesel generator, 1,000 kg/hr packaged boiler, storage tanks for water and fuel).*

FibreFuel www.fibrefuel.co.uk
*(opened in 1995 as a wholly owned subsidiary of Slough Heat and Power. Can take a wide range of wastes, which is shredded and densified into small odourless cubes).*

Foster Wheeler
*(gasification of prepared RDF in a circulating fluidised bed at atmospheric pressure. Main reference plant in Finland with RDF based on plastics, paper, cardboard and wood).*

GEM (Graveson Energy Management). energy@gem-ltd.co.uk www.gem-ltd.co.uk
*(pre-treatment + thermal drying, continuous feed + fast pyrolysis in externally heated reactor. Test plant in Bridgend not in operation, pilot plant in Romsey).*

Greenfinch Ltd. Biogas@greenfinch.co.uk www.greenfinch.co.uk
(*small scale demonstration plant in Ludlow Shropshire, 1,200 households, October 1999 - April 2001. (in 2003 promoting its role in dealing with ABPO and food waste).*

Grupo HLC Henley Burrowes Limited. f.bluck@hlchb.com
*(operating materials recovery and energy centre in Neath Port Talbot, with 70% of input wastes recovered via recycling, composting and RDF. Recent collaboration with Compact Power).*

Herhof, avrilbanks@herhof-uk.fsnet.co.uk www.herhofenvironmental.com
*(in Germany in mid-1990's, receiving mixed MSW, uses a bio-drying stage (with its origins in composting technology) to reduce the mass to produce a fuel fraction ('stabilat') and potentially recoverable fractions (ferrous, non-ferrous, inerts and glass).*

IET Energy/Entech
*(minimal or no waste pre-treatment, but can be used to recover recyclables, with thermal reactor + power generation. About 145 plants process a variety of waste, with at least 8 processing at least some MSW latter all under 25,000 tonnes per annum).*

inetec (innovativeenvironmentaltechnologies) sales@inetec.co.uk www.inetec.co.uk
*(on on-site method of processing all types of food waste and packaging to stable fuel and then to renewable energy).*

*(Jarshire has developed a self-powered multi-material waste management mobile MRF, housed in a transportable customised container up to 40 feet long)*

Leicester . mick.davis@biffa.co.uk
*(mixed waste is fed into a ball mill, and after screening metals, paper and plastics and organic material are separated. The organic fraction is broken down further and transferred via enclosed containers for anaerobic digestion mixed with sewage sludge).*

Linde
*(MBT and anaerobic/aerobic biological processing plants. Number of reference plants in Austria, Germany and Switzerland).*

Lurgi www.lurgi.uk
*(up to 19 types of RDF used, gasification in a circulating fluidised bed. One reference plant in Germany producing syngas and char for a cement kiln. Lurgi(UK) has been appointed as the engineering, procurement and construction contractor for the new Allington energy from waste plant in Kent, with Finnish power company Fortum appointed to operate and maintain the contract.).*

Mitsui Babcock Energy Ltd.
*(waste shredding in roray kilm, metals recovery from char, combustion of syngas and char in second chamber to melt ash into a slag Several plants in Japan, 40 - 110,000 tonnes per annum)*

Nippon Steel
*(a vertical shaft furnace system where waste is directly melted with coke and limestone and the ashes converted into non-toxic slag and metal for recycling, with gas being available for electricity generation. Fly ash is the only residue).*

Oaktech Limited www.arrowbio.com www.oaktech-environmental.com
*(first full scale plant commissioned in Tel Aviv in January 2003. Water is integral to the process and uses 'up-flow anaerobic digestion' to produce a clean, odourless and fully stabilised material. Use as a soil improver and/or biofuel)*

ReCycled Refuse International
*(The process includes solid wastes being continually processed in a fixed bed oxygen-blown gasification and residue melting reactor to achieve a maximum recovery of recyclable materials, with simultaneous utilisation of the chemical energy contained within the wastes).*

Remtec
*(US technology, with a pilot plant operating in Sheffield in 2000-200, and early involvement with Bridgend plant. Accepts raw unsorted MSW which is loaded into a series of rotating autoclaves, and through steam sterilisation volume is reduced. Materials are then post-treated with a series of screens, overband magnets, and eddy current separators. The 'municipal fibre' can be used a raw material or as fuel via pyrolysis or mixed with coal into briquettes).*

R U Recycling
*(subsidiary of E Harper (York) Ltd, specialises in dual stream kerbside collection and processes the co-mingled glass, cans and plastics stream utilising an Andela Co-mingled Separation System (from company's sister firm Andeka products in the USA), a fully automated MRF capable of processing in excess of 20,000 tonnes per year. Uses the Heil Euro-Recycler, and provides services to Blackburn and Darwen Borough Council).*

Shanks. www.shanks.co.uk
*(the Ecodeco/Biocubi process, called the Intelligent Transfer Station in the UK. Waste is received in a controlled environment on an elevated and perforated floor through which air is drawn through the waste. After shredding the homogenous material is moved to aerobic fermentation (bio-drying) followed by materials recovery through sieving, weight separation and metal extraction. The stabilised waste fraction can be landfilled or sent for conversion as Secondary Recovered Fuel ).*

Sterecycle. Info@sterecycle.com www.stereycle.com
*(The process involves steam conditioning autoclaves followed by a MRF for sterilised dry recyclables and separate processing of organic fibre. This latter could include use as a compost, separating long paper fibres for recycling, anaerobic digestion, gasification or converting the organic fibre into briquettes as RDF/SRF).*

Sustainable Environmental Systems LTD. (SES)
*(several in-vessel composting plants in North America, Europe and Japan, 200,000 tonnes per annum).*

SWERF in Canterbury. www.brett.co.uk
*(see under Brightstar)*

Techtrade
*(for UK see Wastegen. One reference plant in Germany since 1984).*

teg environmental plc rcb@tegenvironmental.co.uk www.teg-environmental.com
*(daily loads are shredded by an overhead feeder on to the hot zone of composting material in each Silo-Cage and descends in the appropriate residence time, maintaining continuos operation).*

Tetronics www.tetronics.com

*(established some 35 years and uses plasma arc (DC) technology for the treatment of hazardous waste, recovery of valuable metals and the vitrification of any remaining residues. There are over 80 reference sites around the world. The company is based in Faringdon, near Oxford. Moving into other waste streams ?)*

Thermoselect. www.thermoselect-karlsruhe.de www.thermoselect.com
*(The process includes solid wastes being continually processed in a fixed bed oxygen-blown gasification and residue melting reactor to achieve a maximum recovery of recyclable materials, with simultaneous utilisation of the chemical energy contained within the wastes).*

Thermsave. www.Thermsave.com
*(operational plant in Bridgend,originally linked to Remtec, but now using UK-patented technology. Input wastes are sanitised via autoclaves and extraction of recyclables and RDF. RDF can be burnt directly, mixed with coal into briquettes or converted to syngas for power generation. Alternatively 'RDF' can be used for AD or reconstituted as wood substitute. Two commercial plants in Japan (one at 100,000 tonnes per annum) and one in Germany).*

TPS Termiska
*(RDF receiving, storage and feeding + gasification using circulating fluidised bed + syngas combustion + power generation. One reference plant processing RDF in Italy).*

UR-3R (Urban Resource – Reduction, Recovery and Recycling)
*(GRL Investments Pty Limited ('Global Renewals) is owned by Australian companies GRD and Hastings Funds Management. A range of process steps that result in the reocery of dry recyclable materials from incoming mixed waste, the production of Organic Growth Media (OGM) and the generation of electricity. 80% diversion of waste from landfill)*

WASTEC Ltd.,. contact@wasteconversiontechnologies.com
*(has a bag splitter to deal with incoming mixed MSW, followed by the Wastes Kinetic streamer which pre-sorts materials into two dissimilar streams (flimsy materials such as paper, cardboard, plastic film and garden wastes and rigid materials such as metals, cans, plastic and glass containers). The flimsy materials then go via a trommel, eddy current separator and vibrating screen from the front of the trommel. Rigid materials from the trommel sides are delivered to a vibrating screen, air separator, picking line and eddy current separator. Organic material suitable for in-vessel processing (aerobic or anaerobic).*

Wastegen UK Ltd. Contact : colin.hygate@wastegen.com www.wastegen.com
*(long track record of operating a pyrolysis plant at Bergau in Bavaria since 1983. Promotes the role of Material and Energy Recovery Plants (MERPS), comprising a MRF a pyrolysis palnt as the core unit of 50,000 tonnes and a power generation plant, and the web site contains a full schedule of 50 reference plants).*

**Annex 1. Waste Treatment Requirements, Article 6 (a) of The Landfill Directive**

Draft Guidance from Environment Agency : Waste Treatment must conform to 'the three point test' (as per Article 2 (h))

1. It must be a physical/thermal/chemical or biological process including sorting
2. It must change the characteristics of the waste
4. It must do so in order to :

   reduce its mass, or
   reduce its hazardous nature, or
   facilitate its handling, or
   enhance its recovery

Decisions to be based on BPEO and BAT + waste hierarchy

=1) reduction of quantity of waste landfilled
=1) reduction in hazardousness of waste landfilled (by removing hazards and risks)
3) reduction of hazardousness of waste landfilled (by reducing risks)
4) enhance recovery
5) facilitate handling

**Annex 2. Mayer Parry Recycling : Reasoned Opinion by the European Court of Justice published in July 2002**

- steel packaging is <u>not</u> recycled within the meaning of the Packaging and Packaging Waste Directive

  "when it has been rendered suitable for use as a feedstock,
  but has been recycled only when it has been used by a steel maker
  so as to produce ingots, sheets or coils of steel"

- sorting, cleaning, cutting, crushing, separating and baling are <u>not</u> recycling and the material remains "waste"

- confirmed in June 2003 :

  recycling within the meaning of Article 3(7) of European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste is to be interpreted as not including the reprocessing of metal packaging waste when it is transformed into a secondary raw material such as material meeting the specifications of Grade 3B, but as covering the reprocessing of such waste when it is used to produce ingots, sheets or coils of steel

  That interpretation would be no different if the concepts of recycling and waste referred to by Council Directive 75/442/EEC of 15 July 1975 on waste were taken into account

## Annex 3. Pyrolysis and Gasification

These are 'advanced thermal conversion technologies' which represent alternatives to mass burn incineration. Waste is transformed into gas (syngas), which is then available for combustion. Flue gas volumes and gas cleaning equipment requirements are less than with incineration. Emissions are thus minimised, hazardous components are sterilised, organic waste is minimised and value recovered from the wastes. Some residual wastes and waste water are produced. They can be separate operations or combined.

Pyrolysis
This transforms organic waste to a medium calorific gas (syngas), liquid and a char fraction. The process is endothermic and requires additional energy input. This can be self-standing, but is normally followed by a combustion step and in some cases extraction of pyrolitic oil. The waste needs to be coarsely shredded before entering a reactor operating under atmospheric pressure. In the absence of oxygen the waste is dried and transformed at 400/500 - 700/800$^0$C+ by thermo-chemical conversion, i.e. destructive distillation, thermo-cracking and condensation into hydrocarbons (gas and oils/tar) and solid residue (char/pyrolysis coke) containing carbon, ash, glass and non-oxidised metals. Energy recovery is a marginal benefit. Syngas may be used in gas engines to generate electricity.

Gasification
This is a thermal treatment method to transform organic waste to a low calorific gas (syngas), recyclable products and residues. The process is exothermic with heat conversion efficiencies as high as 87%, compared to 20-27% for a mass-burn incinerator, 36% for a large coal-fired power station and 50-55% for a combined cycle gas turbine. Again, normally followed by combustion of the gases in a furnace and possibly internal combustion engines. Coarsely shredded (usually 6-7% moisture content), sometimes pyrolysed, waste, enters a gasifier where it reacts with air, oxygen or steam. The process takes place typically at 800/900 - 1,000/1,100$^0$C depending on the calorific value and use of oxygen (with higher temperatures of 1,400 - 2,000$^0$C). Ash is often vitrified as a solid residue and may be recycled into an industrial or low grade construction application or landfilled. The main difference between these two processes is that by gasification the fixed carbon is also gasified - a similar process to traditional town-gas plants using coal inputs. It is more common to use RDF/SRF than raw waste. . Syngas may be used in gas engines to generate electricity.

| | Pyrolysis | Gasification |
|---|---|---|
| Advantages | better retention of heavy metals in char | better retention of heavy metals in ash |
| | low leaching of heavy metals | low leaching of heavy metals |
| | low calorific gas (8 Mj/kg) | low calorific gas (5-10 Mj/kg) |
| | $C0_2$ neutral energy production | $C0_2$ neutral energy production |
| | less flue gas than incineration | less flue gas than incineration |
| | very limited formation of dioxins and furans | limited formation of dioxins and furans |
| | well suited to difficult waste fractions | well suited to contaminated wood |
| | sterile clinker and other residues | sterile clinker and other residues |
| Disadvantages | waste needs to shredded or sorted | waste needs to be more consistent in nature and shredded or sorted |
| | oils/tars contain toxic/carcinogenic compounds | oils/tars contain toxic/carcinogenic compounds |
| | char reside contains 20-30% of calorific value | solid reside may contain some carbon |
| | back-up fuel supply required at start-up | |
| | relative high cost | high cost |
| | | combustion of product gas generates $NO_x$ |
| | unlikely to be viable for MSW ? | very few non-prototype plants available |

**Annex 4. UK Cement Industry Use of Alternative Fuels**

| **Fuel** | **2001 – Actual Use, tonnes** | **Next 3-5 years – estimates of Potential Use, tonnes** |
|---|---|---|
| Waste derived liquid fuels | 110,000 | 200,000 |
| Tyres | 40,000 | 290,000 |
| Packaging and Packaging Waste | 0 | 500,000 |
| Waste Oils | 0 | 90,000 to 345,000 |
| Meat and Bone Meal, (MBM) | 0 | 140,000 |
| Processed sewage pellets, (PSP) | 0 | 40,000 |
| **Total** | **150,000** | **1,260,000** excluding waste oils<br>**1,515,000** including waste oils |

Source : British Cement Association, reproduced from House of Commons, Environment, Food and Rural Affairs Committee: "Hazardous Waste", Eighth Report of Session 2001-02, HC 919, at page Ev 117.

These compare with use of waste fuels in cement kilns in England and Wales, 1998 - 2002

| | 1998 | 1999 | 2000 | 2001 | 2001 |
|---|---|---|---|---|---|
| tyres | 17,754 | 19,262 | 26,697 | 30,674 | 37,481 |
| waste liquid fuels | 101,902 | 108,162 | 69,698 | 83,502 | 98,345 |
| solid waste | 0 | 329 | 551 | 0 | 7,890 |

Source : ENDS July 2003, p. 41, from House of Commons Written Answer, 18th June 2003, Cols 287-8W.

## Annex 5. Draft Paper Standard EN 643 (March 2002)

The paper mill industry will accept :

- Papers separated at source into established groups
- Newspapers, magazines, white directories
- Printed and unprinted papers, photocopy, computer paper, junk mail paper
- White and brown cartons, tubes, bags, boxes and corrugated boxes
- Papers mixed together but kept separate from all other materials at all points
- Papers mixed together with recyclables but kept separate from all other materials at all points

The industry will not accept :

- Mixed paper and glass collections
- Directories with coloured pages
- Beverage containers unless completely separate
- Paper in bags, but included in general dirty collection systems
- Unseparated paper included in general dirty collection systems

**Annex 6. Mass Balance and Costings for a State-of-the-Art MBT**

Source : eunomia Research & Consulting and TBU Environmental Engineering (2003). Cool Waste Management. A State-of-the-Art Alternative to Incineration for Residual Municipal Waste. Report for Greenpeace.

Based on a Local Authority with an enhanced source separation scheme targeting dry recyclables and biowaste, with the latter fraction declining from 32% to 19%.

Input = 100,000 tonnes

| | | | | |
|---|---|---|---|---|
| Output 1 | opto-electric | plastic bottles | | 2,000 tonnes |
| | | other dense plastic containers | | 2,500 |
| Output 2 | air classifiers, then | paper and card | | 10,300 |
| | wet separation | plastic film | | 5,700 |
| Output 3 | screening 80-200mm | glass | | 1,500 |
| | 60% efficiency | | | |
| Output 4 | 2 magnetic separators | ferrous metals | | 1,500 |
| | 90% efficiency | | | |
| Output 5 | 2 eddy currents | aluminium | | 2,000 |
| | | dry recyclables | | 25,500 |
| | | residuals | 10,600 | |

Input = 62,200 liquids from percolators to Anaerobic Digestion

| | | |
|---|---|---|
| Output 6 | biogas | 3,700 |
| | process water | 18,000 |
| | sand | 3,000 |
| | degradation | 2,500 |
| | for 'composting' | 35,000 |

Input = 35,000 from Output 6 + 10,600 tonnes from Outputs 1-5 = 46,600

| | | |
|---|---|---|
| Output 7 | water loss @ 40% | 18,400 |
| | better quality screenings | 7,000 |
| | (5 - 15 mm) | |
| | residuals | 1,200 |
| Output 8 | stabilised material to landfill | 20,000 |

**Costings, for a 100,000 MBT as outlined above**

The economics of residual waste treatment technologies is very sensitive to site, local and regional issues and to system design and outputs.

| | £ |
|---|---|
| Plant site development | 500,000 |
| Receival & separation building | 4,000,000 |
| Separation | 4,000,000 |
| Percolation/AD building | 2,500,000 |
| Percolation/AD | 4,000,000 |
| Electricity generation | 700,000 |
| Conveyors | 700,000 |
| Composting hall | 3,100,000 |
| Composting equipment | 2,000,000 |
| Maturation | 1,200,000 |
| Refining | 500,000 |
| Air handling/ductwork | 1,000,000 |
| Biofilters | 500,000 |
| RTO | 1,500,000 |
| Mobile equipment | 800,000 |
| Infrastructure, miscellaneous, spares | 1,500,000 |
| | |
| Total | 28,400,00 |

As with most costings for such facilities, no costs are include for land. An interest rate of 7% is assumed. Given the capital items in the design, similar costs would apply down to 40-50,000 tonnes, rather than c. 30,000 tonnes quoted for other designs. No significant economies of scale would be expected for larger sized plants.

Annual costs (including depreciation) are £6,000,000 or £60 per tonne. If revenues from the sale of products are deducted, costs fall to £51 per tonne.

**Annex 7. Proposed Amendment to Waste and Emissions Trading Bill at House of Commons Report Stage**

The amendment was defeated, and was **not** included in the Waste and Emissions Trading Act which received Royal assent in November 2003,but the text gives some of the concerns that surround the potential role of MBT/BMT in contributing to meeting the Landfill Directive targets.

Clause 21, page 14, line 43, at end insert -

*'(1A) In determining whether waste is biodegradable for the purposes of this chapter the following is to be excluded –*

*(a) waste that has had its biological activity significantly reduced through in vessel accelerated aerobic or anaerobic decomposition from which emissions have been contained; and*
*(b) is within statutory limits of biological activity that the Secretary of State may specify by regulations.*

**Notes on the Amendment**

Reason for Amendment:
There is concern that the current definition in the Bill of biodegradable waste is absolute and will result in important techniques for stabilising waste through accelerated decomposition being excluded from local authority waste strategies. Incineration, and related thermal processes, would become the only process option apart from recycling in UK law for meeting the Landfill Directive targets.

The purpose of this Amendment is to clarify that the residue from waste that has undergone Mechanical and Biological Treatment (MBT) can be landfilled as **non** biodegradable waste. It seeks parity with residue from thermal treatment processes, which would be landfilled.

Thermal waste treatment processes, such as incineration, produce ash for disposal (30% of the original volume in the case of incinerators). It is not stable, but its instability is chemical rather than relating to biological decomposition. Its disposal represents a major problem.

Biological waste treatment processes, such as Anaerobic Digestion or Mechanical and Biological Treatment, produce a relatively stable, similarly reduced residue.

MBT is an important option for disposal authorities seeking to :-

- avoid or minimise incineration,
- recover value from their waste above that which can be achieved from maximising recycling and composting and
- stabilise and reduce residues requiring landfill

Decomposition is accelerated in a controlled environment inside a vessel. Gaseous emissions such as methane, which would normally escape into the air from a landfill or open compost site, are captured. By the time the residue is ready for landfill or land cover, most of the decomposition has taken place. However, a small proportion of further biological change and decomposition will occur. You can never reach zero. In the words of the Bill it would always be "capable of undergoing anaerobic or aerobic decomposition" even if only to a very small degree.

EU context

Although the Landfill Directive does not give a detailed definition of biodegradable waste, the EU does not wish MBT waste to be included as qualifying biodegradable waste for the targets in the Directive. To provide greater clarity, the Commission has produced a 'Working Document on Biological Treatment of Biowaste' that provides a draft for a Directive on Biowaste planned for 2004. The new Directive will set levels of biological activity below which MBT waste will not be deemed biodegradable for the purposes of the Landfill Directive.

Support for MBT as an alternative to incineration

These technologies are being relied on increasingly in parts of New Zealand, Australia and America as part of a "Zero Waste" Approach. Lancashire County Council is considering using this technology to avoid incineration. Greenpeace, Friends of the Earth and the Guildford Anti Incinerator Network advocate MBT to reduce and stabilise waste residue prior to landfill. The South East England Regional Assembly suggests a preference for Anaerobic Digestion in its draft Waste Strategy. That same document expresses a concern that post MBT waste may not be allowable under the WET Bill.

The drafting of this Bill is being interpreted as requiring thermal waste treatment such as incineration. It would be unfortunate, and surely unintended, if the definitions in this Bill introduced a bias in favour of incineration and stifled MBT and other innovative technologies using accelerated and controlled biological decomposition.

The aim of the directive will be to promote the biological treatment of waste and harmonise national measures concerning its management to limit the impact of biodegradable waste and its management on the environment.

Government support

The Government has said it wants to encourage innovative technologies for treating waste. It will be very unfortunate if this Bill stifles the range of biological decomposition technologies that are poised to play such a crucial role in reducing and stabilising our waste, recovering gas and reducing pollution impacts from our waste.

The Government is asked to support this Amendment or bring forward its own amendment that allows appropriate use of technologies such as MBT to reduce our use of landfill and cut greenhouse gas emissions. This Bill must not restrict treatment options to incineration.