TECHNOLOGY & BUSINESS REVIEW

Mechanical-Biological-Treatment : A Guide for Decision Makers
Processes, Policies and Markets

Annexe D
Process Reviews

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Annexe D
Process Reviews

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We wish to place on record our gratitude to the many process developers, site operators and others who provided information for the preparation of this report. In particular we are grateful to the many individuals who facilitated our visits to reference plants to conduct site appraisals.

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Important Note

The inclusion of a supplier or proprietary process in this report does not constitute a recommendation as to its performance or suitability. Equally, non-inclusion does not imply that that process is not suitable for certain applications.

We welcome information to assist with the preparation of any future editions of this report. The opinions contained herein are offered to the reader as one viewpoint in the continuing debate about how MBT can contribute to a modern integrated waste management system. They are based upon the information that was available to us at the time of publication – and may subsequently change.

A wide ranging study of this type may contain inaccuracies and non-current information - for which we apologise in advance. We are always pleased to receive updated information or corrections about any of the processes reviewed for possible inclusion in future editions of the report.

This Review has been carried out on a completely independent basis. No payment has been or will be accepted from any process company for inclusion of any information or commentary contained herein. As an analyst active in this field, Juniper also provides confidential consulting services to many companies involved in this sector. We have procedures in place to avoid conflicts of interest, to protect confidential data and to provide 3rd parties with dispassionate, independent advice.

TABLE OF CONTENTS FOR ANNEXE D1

Separate Tables of Contents are also included at the start of each Annexe and a Guide to the various sections is included on page D-5.

ABOUT Juniper

Juniper is recognised as a leading source of independent technology reviews and specialist market analysis for the waste management and environmental sectors. Juniper provides business and technical consultancy services to public and private sector clients worldwide. Our services include:

- Analysis of Market Trends & Novel Technologies
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- Partner Identification – across geographical and business boundaries
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ABOUT SITA Environmental Trust

SITA Environmental Trust commissioned this report in 2004 to provide answers to the many outstanding questions about the future for MBT in the UK.

SITA Environmental Trust distributes funding through the Government's Landfill Tax Credit Scheme (LTCS). All the Trust's funding is donated by the waste management company, SITA UK.

SITA Environmental Trust:

- Is one of the largest distributors within the LTCS handling circa 10% of all funds in the Scheme
- Has allocated over £40M to more than 900 projects since 1997
- Has been a strong and focused investor in sustainable waste management projects
- Is planning to invest circa £30M over the next five years in community and environmental improvement projects across the UK

For more information about the Trust and details of other projects it has funded, please visit www.sitaenvtrust.org.uk

ABOUT ASSURRE

ASSURRE (The Association for the Sustainable Use and Recovery of Resources in Europe), based in Brussels, is a partnership for action, which aims to play an important role in transforming Sustainable Resource Management from a concept into a practical process and to work for a better EU legislative framework through improved dialogue between all relevant actors and the EU institutions.

ASSURRE's approach is to:

- Raise the level of informed debate as regards the key issues of sustainable resource management and feed expertise into the EU institutions
- Uphold the vital link between EU policy formulation and implementation and ensure that experiences on the ground are fed back into the decision-making system.
- Commission Best Practice case studies and share lessons learned
- Track key issues and developments in technology and policy

For more information about Assure please visit www.assurre.org

Format of the Report : electronic, downloadable pdf

This report consists of a **Summary Report**, **4 Annexes** and an **Executive Summary**.

All parts of the report can be downloaded free of charge from the SITA Environmental Trust (www.sitaenvtrust.org.uk), ASSURRE (www.assurre.org) or Juniper (www.juniper.co.uk) websites (please bear in mind the file size when downloading!). Alternatively a CD-ROM containing a complete set of files is available to order from Juniper at a nominal charge.

Section	Scope
The Summary Report	Contains key findings about the role that MBT can play, assesses recycling and diversion performance, and reports on the issues and challenges that will affect its wider adoption
Annexe A: Process Fundamentals	Details the types of MBT system, related technologies and their key differences.
Annexe B: Issues arising out of the Regulatory & Policy Framework	Identifies and discusses the key EU and UK policy initiatives and regulations and assesses their impact on the uptake of MBT.
Annexe C: An Assessment of the Viability of Markets for the Outputs	Examines market constraints, technical obstacles & considers supply and demand issues related to fuel and soil improver applications
Annexe D: Process Reviews	Provides independent reviews of 27 commercial MBT processes and comparative analysis of these
Executive Summary	Summarises key conclusions

D1 Introduction

D 1.1. The purpose of this Annexe is to provide the reader with independent assessments of the processes being marketed by 27 suppliers of proprietary MBT systems. These assessments have been based on:

- prior information held in the Juniper database;
- visits to reference sites to conduct site appraisals;
- information provided by the process supplier about their process(es);
- discussion with plant operators and others;
- information from other public domain sources.

D 1.2. This Annexe is one section of a report on MBT processes and their suitability for managing MSW, which seeks to provide **a comprehensive, objective review of the capabilities and limitations of MBT technologies in the context of evolving waste management requirements**. Details of the other parts of this report, and how to obtain them, are on the previous page.

D 1.3. This study was funded by UK landfill tax credits disbursed by **the SITA Environmental Trust (SET)** and co-funded by **ASSURRE** (The Association for the Sustainable Use and Recovery of Resources in Europe). We are grateful to both organisations for their support.

D 1.4. We are very grateful to the process companies and to the operators of the plants we visited for the time spent in providing information and in facilitating visits for us to reference sites as well as for their patience in responding to our many clarification questions!

D2 Summary of Key Performance Parameters

D 2.1. In this section we aim to provide the reader with a summary of the performance parameters of the MBT systems that we have reviewed. We have not set out to rank the attractiveness of each technology according to one or more criteria – this will vary from project-to-project – but rather to classify systems by their functionality and highlight the performance of each system.

D 2.2. It is not meaningful to compare all processes against all parameters in a quantitative fashion since many of these systems have been developed with different objectives, for specific regional or market requirements, and performance data has often been derived from reference plants that are operated on waste streams with different characteristics. For example, one system may aim to maximise biogas production from mixed MSW, while another seeks to achieve a highly stabilised output from 'grey bag'[1] waste.

D 2.3. It will therefore be incumbent upon the Local Authority and its advisors to select a process which performs best against the relevant parameters that are most important in relation to its waste management objectives, taking into consideration bankability and provenness.

D 2.4. The main parameters that we have chosen to highlight in this section are:

- How proven are different MBT systems?
- Which configurations appear to be most popular?
- What is the potential recycling performance of MBT facilities?
- How much waste could be diverted from landfill?
- How much biogas could be produced?
- What is a typical plant footprint?
- Where is MBT most proven?
- Where are new projects being announced?
- How long does it take to process the waste to achieve the desired primary output?
- What are the reported economics?

D 2.5. Because this report has been prepared for the public domain, many of the suppliers chose to withhold information about the performance of their process. Such instances are clearly identified within the individual process reviews.

[1] The residual fraction of household waste, after some level of separation by the householder for recycling

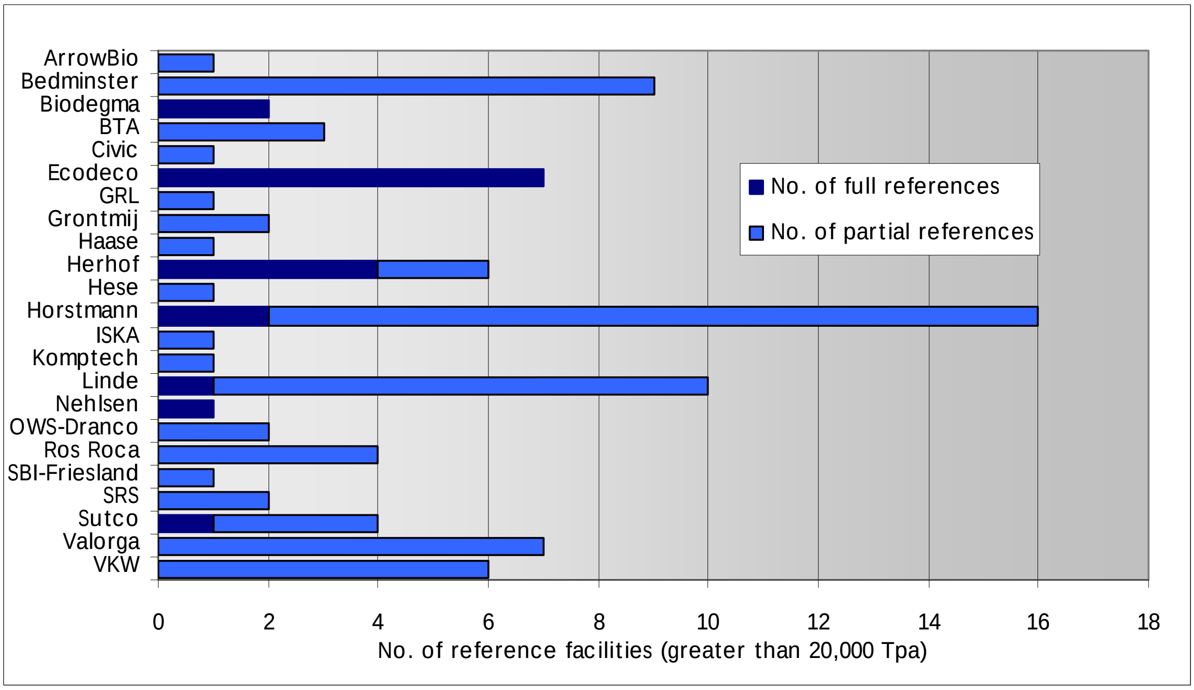
Reference plants

D 2.6. Twenty-three of the 27 companies we reviewed have at least one operating reference facility treating MSW. Although in some cases, a single company has delivered all of the core treatment technologies to a plant on a turnkey basis, it is common for several companies to partner for a specific project, each supplying a different part of an integrated process. Because of this, there are a number of plants which are claimed as a reference by more than one supplier.

D 2.7. Distinguishing between varying levels of involvement at particular MBT plants is important in the context of assessing the ability of a company to deliver on a project.

D 2.8. In our comparisons of the provenness and operational track-records of different process companies, we have taken this into consideration by labelling a plant as either a 'partial' or 'full' reference. Figure D1 summarises our analysis. To be a full reference, the company must have supplied all of the core treatment components and integrated them on a turnkey basis, the plant must have completed commissioning and be operational on a commercial basis.

Figure D1: Operational references by supplier



Source: Process Reviews

D 2.9. Plants may be characterised as a partial reference for a variety of reasons. These include:

- it may not yet have completed commissioning
- the scope of supply for that company was limited (for example, they were only responsible for the biological element)

- the plant has only operated for a limited period of time as a demonstration facility
- the plant is configured to co-process MSW with other organic wastes (e.g. sewage sludge or commercial kitchen waste)
- a company developed the underlying technology, but the project was installed and developed by a licensee
- the company is primarily a marketing agent for the underlying technology
- the facility was not supplied on an arms-length contract basis
- the process requires a significant quantity of bio-solids for effective treatment of MSW

D 2.10. Although not particularly well-known within the UK, the German engineering firm **Horstmann** has more references than any other MBT supplier. Two of their reference facilities were supplied on a turnkey basis while only a part of the plant was supplied at 14 other facilities.

D 2.11. **Ecodeco** has supplied the most plants on a turnkey basis, as this is their primary business model. Furthermore, the configurations of their plants have been predominantly consistent from reference to reference.

D 2.12. It should be stressed that the information provided in Figure D1 is based on **MBT** references treating predominantly **MSW**. A number of suppliers, such as **BTA, Biodegma, OWS** and **Sutco**, have significantly more experience supplying stand-alone AD and composting units for treating other organic wastes, which require very little, or no, mechanical pre-treatment. This experience base is undoubtedly valuable in successfully delivering components for an MBT plant. More information on these non-MSW reference facilities can be found within the respective process reviews.

D 2.13. **Bedminster's** reference plants mainly co-compost sewage sludge with MSW and have varying levels of mechanical pre-treatment. All of their plants are located outside of Europe.

D 2.14. There are also a number of companies, for example, **Ros Roca** and **Valorga**, that have technologies proven for treating other waste streams, but who are adapting it to MSW applications. Ros Roca is an example of a substantial waste management company which acquired an AD technology proven for treating biowastes through the purchase of Envital, the original technology license holder. Ros Roca has implemented this AD technology at three MSW references since the acquisition, with three more planned.

D 2.15. **SRS,** a much smaller company, are the UK agents for the Wright Environmental in-vessel composting system, which has operated successfully on a number of organic waste streams. Unlike Wright Environmental, SRS is now promoting the process for MSW.

D 2.16. **Linde**, one of the most substantial engineering firms in this report, has acquired a portfolio of technologies from which to choose an optimal solution on a project-by-project basis. To date, the company has supplied their process technologies to 27 plants treating MSW. Of these, more than ten were confirmed by Linde to be operating.

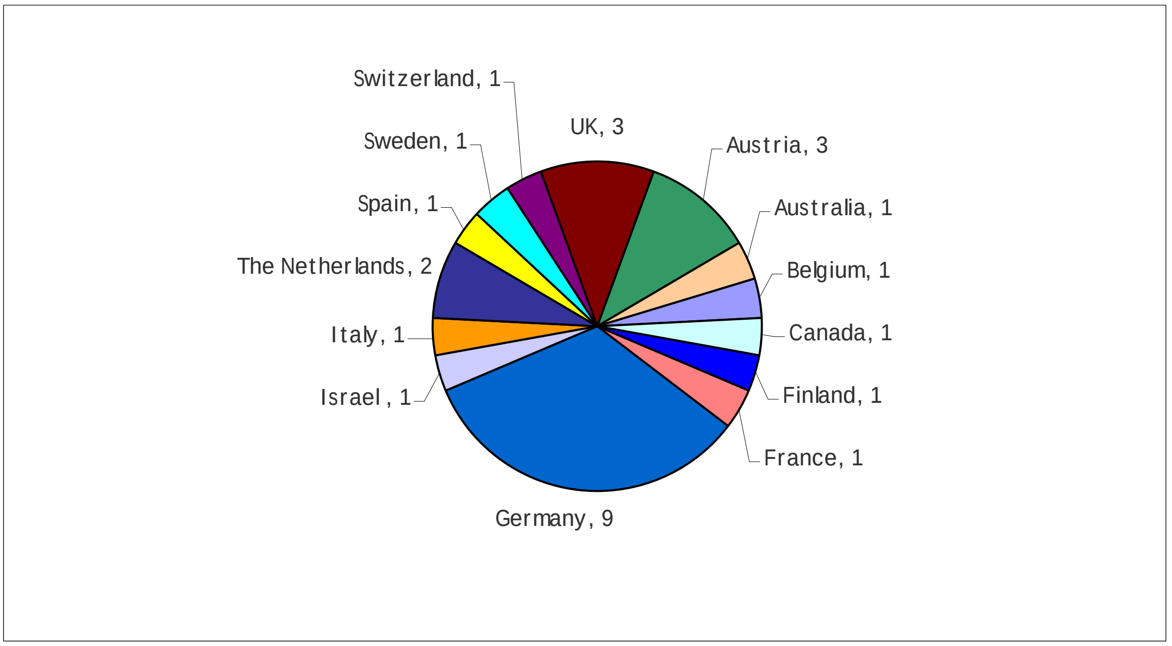
D 2.17. **Wehrle** do not appear in Figure D1, as they do not currently have an operational reference plant. They have operated an MBT demonstration plant and they are now building their first commercial reference.

From where do the technologies originate?

D 2.18. One-third of the technologies reviewed originate from Germany (see Figure D2), which is not surprising considering this is where much of the historical development of integrated mechanical and biological treatment of waste has taken place.

D 2.19. So far, UK companies have less demonstrated experience supplying MBT processes than many of their continental counterparts. None of the three UK technologies would be characterised yet as fully commercial according to Juniper's technology classification (see Figure D6).

Figure D2: MBT technology by country of origin[1]



Source: Process Reviews

Where are suppliers' references?

D 2.20. There are **80 MBT plants operating in 16 countries**, installed by the 27 suppliers reviewed in this study, **processing more than 8 million tonnes of waste per year**.

[1] Information in this figure is based on where the technology originates. The companies promoting these systems may be headquartered in different locations.

D 2.21. The large majority of this infrastructure has been installed in continental Europe with approximately two-thirds of the world's combined operating capacity built in Germany, Italy and Spain.

D 2.22. **Spain** is home to six of the world's ten largest MBT facilities. This includes the current largest plant, in Madrid, which was supplied by **Horstmann** with an input capacity of 480,000 Tpa. The next largest facility has a capacity of 300,000 Tpa, is located in Barcelona and was supplied by **Linde**.

Figure D3: Number of operating MBT facilities[1,2]

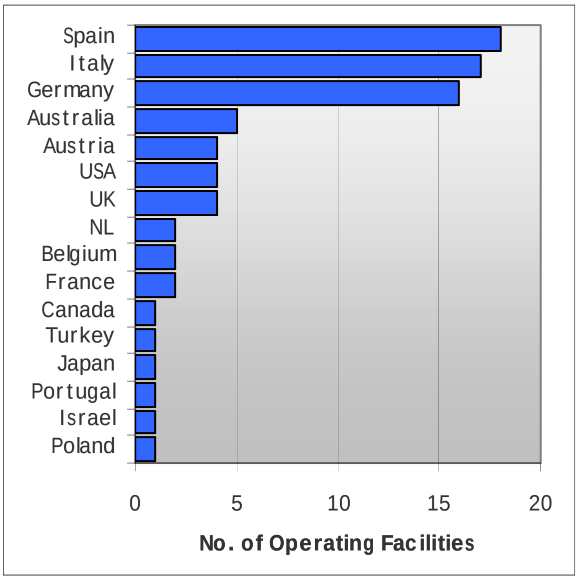
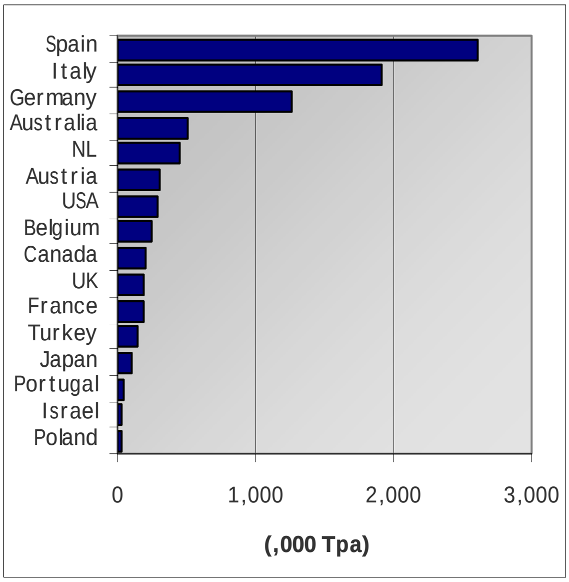


Figure D4: Total installed MBT capacity by country[1,2]



Source: Process Reviews

D 2.23. The largest of the **Italian** plants treats 270,000 Tpa for which VKW supplied their composting process. This facility is one of five reference plants using their technology in Italy, all of which produce a bio-stabilised output which is sent to landfill. Eight other plants have been built to produce a fuel (SRF) using bio-drying. Seven of these have been built by **Ecodeco** and one was built by **Herhof**. The scale of these facilities range between 60,000 and 150,000 Tpa.

D 2.24. The Ca' del Bue plant in Verona is one of the largest MBT sites we visited during this study. This facility treats 175,000 Tpa of MSW and incorporates an AD element supplied by BTA. This plant is fully integrated and includes RDF production, which is combusted on-site along with the digestate from the AD unit.

D 2.25. The largest operating plant in **Germany**, supplied by **Sutco and RWE**, has a capacity of approximately 200,000 Tpa. However, the majority of the remaining German plants have

[1] Other studies have reported higher numbers but we believe these include simpler composting plants that have some mechanical sorting associated with the process, which we have not considered in this report.
[2] These 80 plants represent the bulk of the installed capacity, although there may be some others installed by companies not included in this review.

been built at smaller scale. Considering the amount of attention focused on MBT activity in Germany, it is surprising that only two of the world's 25 largest plants are located there.

D 2.26. Elsewhere there has been much less interest in MBT. There have been four plants built in the US; all of these utilise **Bedminster's co-composting technology**. These would not normally be described as 'MBT', a term that is largely unknown outside Europe, but are functionally the same as the European MBT plants and, for this reason, are included here. Bedminster's technology has also been used in three of Australia's five plants.

D 2.27. **Belgium, The Netherlands and France** each have two operating MBT plants. All but one of these incorporates anaerobic digestion as the core treatment technology to maximise biogas production. The one exception is a plant built by **Herhof** in Belgium which is designed to produce an SRF.

D 2.28. **In the UK**, **Hese's** well publicised plant in Leicestershire is somewhat unique in that different components of the MBT process are located at different sites. A demonstration plant built by **Civic Environmental** is also treating waste commercially and the site's operating capacity is set to increase now that an additional line has been installed.

D 2.29. The plant in **Turkey**, located in Istanbul, is a relatively significant reference as it is **VKW's** only facility operating outside of Italy and has a capacity of 150,000 Tpa. The output from this plant is reportedly used as a soil improver.

Announced Projects

D 2.30. A further **43 MBT projects** have been formally announced by the 27 suppliers.

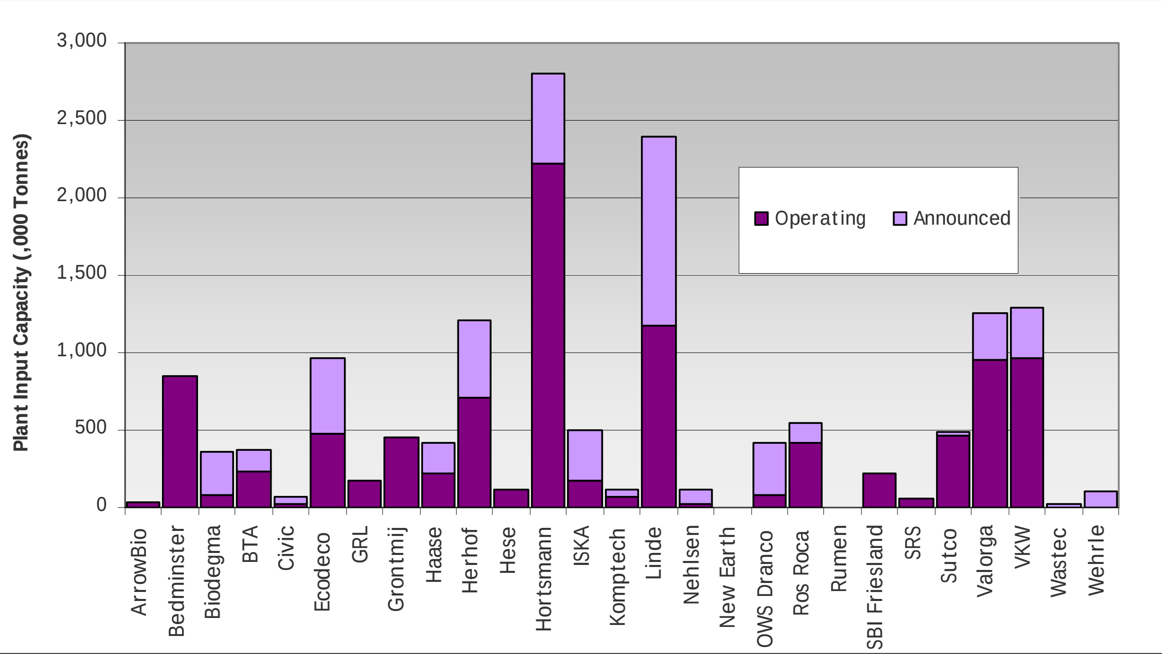
D 2.31. Approximately half of these are in Germany; several at a scale larger than their predecessors. As a result, it is anticipated that over the next two years, Germany is likely to overtake Italy and Spain as the country with the greatest amount of installed capacity.

D 2.32. The 22 plants announced in Germany are references for 12 different MBT companies, indicating that even in one of the most established markets, **no one company has yet to emerge as the market leader**.

D 2.33. According to the information provided by each company, **Linde** currently has the most announced projects under development worldwide. They, like Horstmann, supply both turnkey facilities and component systems for a number of configurations.

D 2.34. In the **UK**, many of the new projects that have been formally announced so far are from **Ecodeco,** via their partner Shanks, including 350,000 Tpa of capacity in the East of London, and a 65,000 Tpa facility in Dumfries, Scotland. There are many other less advanced projects in the UK. However, we have only included in our analysis those which had been formally announced at the time of writing. We therefore exclude projects in which a preferred bidder has been announced but the project has not yet entered formal planning stages.

Figure D5: Operating and announced capacity by supplier[1]



Source: Process Reviews

How proven are the different processes?

D 2.35. We have categorised each of the proprietary processes that were reviewed according to our standard classification system for provenness. Of the 27 companies reviewed, 15 have at least one commercial reference. MBT technologies can therefore be considered more demonstrated than most other technologies being promoted as alternatives to incineration in the UK. However, certain configurations of MBT systems are more proven than others.

Figure D6: Classification of the 27 MBT suppliers reviewed in this report

Status	Description	Process Supplier
Fully Commercial	Two or more commercial facilities that have both operated for more than one year	Bedminister, Biodegma, BTA, Ecodeco, Grontmij, Herhof, Horstmann, Linde, OWS, SRS, Valorga, VKW
Commercial	One commercial facility operating for a period greater than one year	Nehlsen, Ros Roca, SBI Friesland, Sutco
Demonstrated	A full scale trial plant (or module) has been operated for a period of time	ArrowBio, Civic, Komptech
Market entrant	While the company has received at least one commercial order they have not yet completed commissioning their first plant	GRL, Haase, Hese, ISKA, Wehrle
Conceptual	Has promoted an MBT solution	New Earth, Rumen, Wastec

Source: Juniper database

[1] Calculated according to the designed input plant capacity

At what scale are different processes proven?

D 2.36. The scale at which different MBT facilities are built is a function of the technology type, the local needs of the community and the availability of waste. For this reason, most MBT systems have been designed to be modular and can be scaled up or down to meet different requirements.

D 2.37. The majority of MBT plants have been built at a scale between 20,000 and 100,000 Tpa, although there has been a significant amount of experience configuring plants at larger capacities greater than 200,000 Tpa. No MBT plant has yet to operate at a scale comparable to the largest waste incineration plants (greater than 1,000,000 Tpa). In Figure D7 we show at which scales the 27 suppliers have demonstrated or announced capacity.

Figure D7: Demonstrated and announced capacity by process supplier

	< 50,000 Tpa	50,000 to 100,000 Tpa	100,000 to 200,000 Tpa	>200,000 Tpa
ArrowBio	● (magenta)			
Bedminster	● (blue)	● (blue)	● (blue)	
Biodegma	● (blue)	● (magenta)		● (magenta)
BTA	● (blue)		● (blue)	
Civic	● (blue)			
Ecodeco	● (blue)	● (blue)	● (blue)	
GRL			● (blue)	
Grontmij				● (blue)
Haase		● (magenta)	● (magenta)	● (blue)
Herhof		● (blue)	● (blue)	● (magenta)
Hese			● (blue)	
Horstmann	● (blue)	● (blue)	● (blue)	● (blue)
ISKA	● (magenta)		● (blue)	
Komptech		● (blue)		
Linde	● (blue)	● (blue)	● (blue)	● (blue)
Nehlsen	● (blue)	● (magenta)		
OWS	● (blue)	● (blue)	● (magenta)	
Ros Roca	● (blue)	● (blue)	● (magenta)	● (blue)
SBI				● (blue)
SRS	● (blue)			
Sutco	● (magenta)	● (blue)	● (blue)	● (blue)
Valorga		● (blue)	● (blue)	● (blue)
VKW			● (blue)	● (blue)
Wastec	● (magenta)			
Wehrle	● (magenta)		● (magenta)	

The colour coding system denotes:
● (blue) = One or more operating plants at this scale ● (magenta) = A project has been announced or a demonstrator has been operated

Source: Juniper database

References by Application

D 2.38. One of the most significant differentiating features of an MBT process is the type of biological element that it incorporates. In Figure D8 we list various biological processes that are promoted by the 27 suppliers. A discussion of the relative attributes of these different technologies is presented in Annexe A.

Figure D8: Biological elements used by the 27 suppliers

	Aerobic Composting						Anaerobic Digestion					
	Tunnel	In-Hall	Continuously Agitated	Simple Covered	Bio-drying	Percolation	Wet, Single-stage, Mesophilic	Wet, Single-stage, Thermophilic	Dry, Single-stage, Mesophilic	Dry, Single-stage, Thermophilic	Wet, Multi-stage, Mesophilic	Wet, Multi-stage, Thermophilic
ArrowBio											✓	
Bedminster			✓		✓							
Biodegma				✓	✓							
BTA											✓	
Civic			✓									
Ecodeco					✓							
GRL		✓				✓					✓	
Grontmij								✓				
Haase											✓	
Herhof					✓							
Hese												✓
Horstmann	✓				✓							
ISKA						✓					✓	
Komptech												
Linde	✓			✓						✓	✓	
Nehlsen					✓							
New Earth		✓										
OWS										✓		
Ros Roca	✓						✓					
Rumen												
SBI								✓				
SRS	✓											
Sutco		✓										
Valorga									✓	✓		
VKW		✓										
Wastec			✓									
Wehrle					✓	✓					✓	

Source: Juniper database

Producing a Biogas

D 2.39. **Approximately one-third of the 80 operating MBT plants produce at least some biogas via anaerobic digestion.** The underlying AD technology used, however, varies, depending upon the supplier and the plant configuration. The relative advantages and disadvantages of these different technologies are discussed in Annexe A and within the respective process reviews.

D 2.40. In Figure D9 we have listed those companies that supply MBT plants, which incorporate an AD element, according to the specific type of technology that they promote. The list only includes those companies that have supplied AD technology to a plant that is currently operational or has operated on a demonstration basis.

Figure D9: Operating AD technologies in MBT plants treating MSW

	SINGLE STAGE		TWO STAGE	
	Mesophilic	Thermophilic	Mesophilic	Thermophilic
WET AD	Ros Roca,	Grontmij, SBI	ArrowBio, BTA, GRL*, Haase, ISKA*, Linde, Wehrle*	Hese
DRY AD	Valorga	Linde, OWS, Valorga		
* These three companies utilise percolation ahead of the digester, in which some hydrolysis takes place. Note: Where a company is listed in more than one box, they offer more than one configuration				

Source: Juniper database

D 2.41. **Valorga's** technology has operated with both mesophilic and thermophilic bacteria although in the same dry single-stage configuration.

D 2.42. **Linde** is unique in that it can offer AD on both a wet and a dry basis. But in practice, its wet technology has been implemented far more frequently, being incorporated at most of its Spanish references. Linde's wet AD technology is also widely demonstrated for a variety of bio-wastes. Their dry digestion technology is only operating at one MSW reference plant and is usually the preferred solution only if land availability is a significant issue for the plant.

Figure D10: MBT suppliers with operating reference sites using AD

Suppliers	Country of origin	Number of reference sites	Location of site(s)
OWS	Belgium	2	Germany
Linde	Austria	4	Spain
Ros Roca	Spain*/Germany	4	Spain
BTA	Germany	3	Italy, Poland
Valorga	France	7	France, Spain, Belgium, Italy
Haase	Germany	1	Spain
* The technology is owned by Ros Roca Spain but the MBT process in being marketed from the company's German office.			

Source: Juniper database

D 2.43. The amount of biogas that can be produced varies from process-to-process. We discuss this issue below and within Annexe A.

Bio-drying to produce an SRF

D 2.44. While there are many companies that produce a fuel fraction, only three of the 27 reviewed uses bio-drying to produce an SRF (see C2 in Annexe C) and these are listed in Figure D11. Our understanding is that Bedminster, Biodegma, Horstmann and Wehrle are also promoting this type of MBT plant. Biodegma's first bio-drying reference plant is planned for Neumünster in Germany in 2005.

Figure D11: MBT suppliers with operating reference sites producing SRF

Suppliers	Country of origin	Number of reference sites	Location of site(s)	Input Capacity (Tpa)
Ecodeco	Italy	7	Italy	40,000 – 120,000
Herhof	Ireland*/Germany	6	Germany, Italy, Belgium	85,000 - 150,000
Nehlsen	Austria	1	Germany	20,000
* The technology was developed in Germany but is now owned by the Irish company Herhof Environmental.				

Source: Juniper database

Bio-stabilised output for landfilling

D 2.45. Producing a bio-stabilised output for landfilling is among the most common applications of MBT, because of its widespread use in German, Austrian and Italian markets. The legislative issues driving this are discussed in greater detail within Annexe B3.

Figure D12: MBT suppliers with references producing a bio-stabilised output for landfilling

Suppliers	Country of origin	No. of reference sites	Location of site(s)	Input capacity (Tpa)
Biodegma	Germany	2	Germany	40,000 – 85,000
Hortsmann	Germany	4+	Austria, Germany, Italy	40,000 – 65,000
Linde	Austria	3	Germany, Austria	70,000 – 150,000
OWS	Belgium	2	Germany	20,000 – 60,000
Sutco	Germany	1	Germany	22,000*
VKW	Austria	5	Italy	135,000 – 270,000
* This plant is being expanded to treat 40,000 Tpa				

Source: Juniper database

D 2.46. Figure D12 lists the various suppliers that have operating reference plants producing a bio-stabilised output for landfill from MSW (at the time of writing).

D 2.47. Of these six process suppliers, only **OWS and Linde** have been configured with an intermediate anaerobic digestion stage. In such configurations, it is the digestate from the AD plant that is bio-stabilised. The remaining processes typically are configured with the primary goal of bio-stabilising the entire organic fraction, in order to meet local landfill diversion objectives.

Processes that make a bio-treated output for use on land

D 2.48. On the basis of installed treatment capacity, plants which are configured to produce an output for land-use applications are the most common type of MBT. This is in large part because of the substantial capacity in Spain where there is significant need for soil-like materials to prevent desertification. However, use of MBT outputs on land is not confined to the Spanish market as is shown in Figure D13.

D 2.49. This analysis includes plants which utilise the compost-like output as daily landfill cover. The viability of land use applications from a commercial, regulatory and technical perspective can be found within Annexe C.

Figure D13: MBT suppliers with operating reference sites producing CLO[1]

Suppliers	*Country of origin	Number of reference sites	Location of site(s)	Input Capacity, Tpa
Bedminster	Sweden	8	US, Australia, Canada	30,000 – 120,000
Civic	UK	1	UK	22,000
GRL	Australia	1	Australia	175,000
Horstmann	Germany	c. 8	Spain	25,000 - 480,000
Linde	Austria	2	Spain, Portugal	45,000 – 75,000
SRS	Canada	2	UK	25,000 – 35,000
VKW	Austria	1	Turkey	150,000
* Denotes where the core technology was developed not where the company promoting the technology is based				

Source: Juniper database

D 2.50. We have summarised the state of the market based on operating reference facilities and the outputs they produce in Figure D14.

[1] CLO = Compost-Like-Output

Figure D14: A summary of MBT projects by process company

Company / No. of References	Make a fuel	Make a CLO	Produce biogas to generate electricity	Make a bio-stabilised output for landfilling
ArrowBio **1**		Its one plant treats c. 35 kTpa of MSW and uses the AD digestate as a soil improver in Israel	Somewhat unique reference because of the long residence time in the AD reactor which results in a high biogas yield	
Bedminster **9**	One reference operating in Japan makes a 'bio-fuel'	All but one reference co-composts MSW and sewage sludge		
Biodegma **2**	A plant planned for Neumünster will be configured to maximise fuel production			Existing references mainly produce a bio-stabilised output although RDF is also an output
BTA **3**			Has only supplied AD sub-systems at two of its references and their complete AD system at one other	
Civic **1**	Its UK demonstration plant separates out a fraction which could be suitable as an RDF but currently goes to landfill	The bio-treated output from its demo plant is being used as landfill cap in the UK		
Ecodeco **7**	All 7 references are configured to produce an SRF			
GRL **1**		Digestate from the percolation process at its one plant will be bio-stabilised for a long time with the intention of using it as a compost	Their reference will produce biogas	
Grontmij **2**	Both references separate out an RDF fraction for co-combustion applications in Germany, Scandinavia and the Netherlands		Both references are operated in a similar configuration with the primary goal of producing biogas	
Haase **1**			Supplied the AD system to its first plant, which was in commissioning as of February 2005	Plans to incorporate composting technology along with AD in future turnkey plants
Herhof **6**	All six references are configured to produce an SRF			

Company / No. of References	Make a fuel	Make a CLO	Produce biogas to generate electricity	Make a bio-stabilised output for landfilling
Hese **1**		The AD digestate produced at the Leicestershire plant is sent for maturation to be used as a blended soil improver	Its plant in Leicestershire incorporates AD although the pre-treatment stage is at a different site than the digester	
Horstmann **16**	One German reference plant produces a fuel	Has supplied tunnel composting technology at many reference plants		c.5 reference plants produce a bio-stabilised residue for landfill
ISKA **1**			Their process design produces biogas	At both of ISKA's plants under construction the digestate from the percolator will be bio-stabilised for disposal in landfill
Komptech **1**				At their one reference, Horstmann's composting technology is integrated with Komptech's mechanical treatment system
Linde **10**		Linde's most recent plants employ tunnel composting which could be used to produce a soil improver	4 of Linde's references produce a biogas output	Linde has supplied several plants that produce a bio-stabilised output
Nehlsen **1**	Nehlsen's one operating plant produces an SRF as the primary output			
New Earth **0**		New Earth's pilot plant demonstrates their composting element to produce a soil improver		
OWS **2**			Have provided the AD component for two MBT reference plants	Is developing a turnkey MBT process which incorporates bio-stabilisation of the AD digestate, although this configuration has only operated at pilot scale
Ros Roca **4**		Their composting process could be used to produce a soil improver	Has an AD process which has been operated at three of its references	

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Company / No. of References	Make a fuel	Make a CLO	Produce biogas to generate electricity	Make a bio-stabilised output for landfilling
SBI 1	Its one reference separates out an RDF fraction for co-combustion applications in Germany and the Netherlands		Its one reference produces biogas	
SRS 2		Both reference plants produce a material that is used as landfill top-cover		
Sutco 4				Has one integrated MBT facility operating which uses their composting process to stabilise the output for disposal in landfill at a small scale plant in Germany
Valorga 7			At all seven references, have only provided the AD technology	
VKW 6		The reference plant in Turkey plants bio-treats the output to use as a soil improver		VKW's Italian references bio-stabilise the output which is normally sent to landfill
Wastec 0	Process is designed to produce an RDF fraction	Promoting an MBT system which incorporates the Hot Rot composting system for producing an output to be marketed as a soil improver		
Wehrle 0	The solid output from the percolator is bio-dried to produce a fuel. A demonstration plant operated for three years in this configuration		Process is designed to produce biogas	

Source: Juniper database

Key Operating Performance Parameters

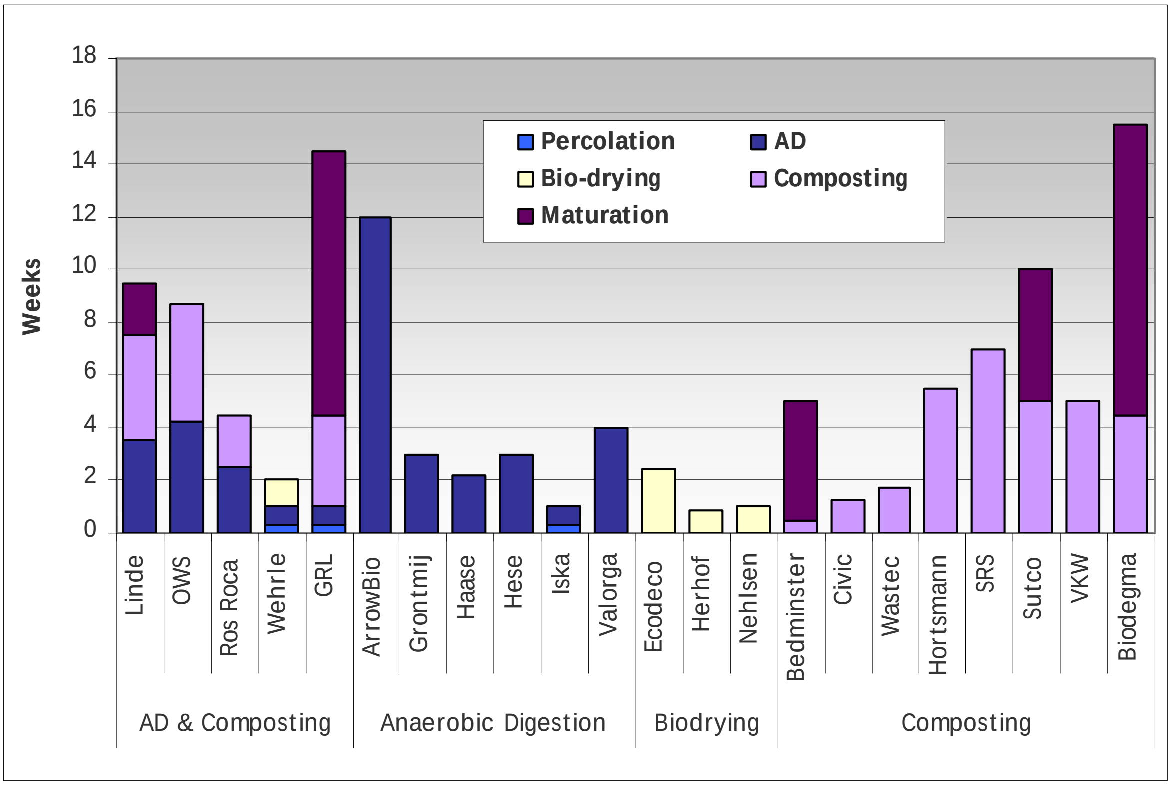
Residence time

D 2.51. The time it takes for waste to be processed within the biological step(s) of an MBT plant is referred to here as the residence time. We believe that **residence time is one of the**

most useful performance parameters that can be used to differentiate between processes, since it is a prime determinant of several other key factors including the extent of the reduction in biodegradability of the incoming waste, the required footprint of the plant, the overall economics and the quantity and quality of the bio-treated outputs.

D 2.52. The residence times of the operating reference plants vary from less than seven days to more than 15 weeks (see Figure D15) reflecting different underlying technologies, commercial objectives and plant configurations.

Figure D15: Indicative residence times of various processes[1]



Source: Process Reviews

D 2.53. To be considered stable enough to be allowed into landfill, most processes must digest the waste for at least 6-8 weeks in Germany and 4-7 weeks in Italy. This heavily influences the way that specific processes have been configured in these countries.

D 2.54. It is important to note, however, that digestion and maturation times could be shortened or lengthened by a particular process supplier to optimise the plant's performance to meet specific local objectives.[2]

[1] Komptech, BTA, New Earth, Rumen and SBI were excluded because insufficient information was available for comparison. See process reviews for additional information about specific processes. Where a range was provided, the median value was used.

[2] As stated by several process suppliers

D 2.55. So, if the same processes were instead selected for UK projects, they could wish to produce a bio-treated output for a compost-like application instead of sending the output to landfill - in which case the residence times could, in theory, be reduced. Consequently, it is not appropriate to assume that the residence times shown in Figure D15 would be the same for a UK project.

What is the demonstrated recycling performance of MBT?

D 2.56. An MBT process can recover as many recyclables as are available in the waste. However, from a commercial perspective, the market acceptability of recyclables varies in different regions, as does the quantity within the waste; and thus the decision to invest in additional sorting and separation equipment to maximise recycling performance is not straightforward.

D 2.57. During our site visits we noted that some process companies in Germany, for example, did not invest in equipment to recover aluminium, despite its high value, because much of the aluminium in German communities' waste is separated out before it gets to the MBT facility. Therefore many of the process companies we spoke with felt that although technically possible, recovering the remaining marginal quantity of aluminium did not justify the associated costs.

D 2.58. For this reason it is unhelpful to compare the demonstrated recycling performance of MBT processes operated outside of the UK. Only following a detailed characterisation of the waste of a particular community, is it possible to determine what recycling performance a specific MBT process can achieve and at what costs.[1]

D 2.59. For informational purposes, we have nevertheless summarised the data contained in the process reviews on the quantities of recyclables recovered by certain processes in Figure D16. A review of the quality of recyclables that can be recovered from MBT plants, and the process parameters that influence recovery, is provided in Annexe A.

D 2.60. Nearly all of the processes we reviewed recover ferrous metals. Some plants choose to separate out paper and light plastics, but only a few choose to separate out glass.

D 2.61. Only one company, ArrowBio, declared a commercial arrangement for the sale of the plastic fraction. The company reported that it receives approximately £55 / tonne from a company in China, which uses the mixed plastics for manufacturing composites.

D 2.62. In addition to the recyclables listed above most MBT plants could also recover an aggregate material mainly consisting of sand and fine glass which in some circumstances could be used in construction applications. This material however, usually ends up in landfill.

D 2.63. It is interesting to note that the two highest levels of metal recovery relate to processes that are being implemented in the UK.

[1] As stated by several process suppliers

Figure D16: Indicative levels of outputs from different MBT systems (wt% of the input)

	Metals	Glass	Paper	Plastics	Biogas	Bio-treated output	SRF	RDF
ArrowBio	3 to 4			9 to 17	9 to 13	8 to 10		
Biodegma	5			5		12		40
Civic	4 to 7	6 to 8				35 to 40		
Ecodeco	3 to 5						50	
GRL	4	2.6	7	7	5	21		
Grontmij	3		15 *		5			42
Herhof	5						50	
Hese	7							41
Horstmann	4 to 5			13				
ISKA	2 to 4				4 to 7			44 to 62
Nehlsen	5						55	
OWS	6				12			
SBI	3		16 *		6			43
SRS	1 to 3					12		
Sutco	2 to 3					32.5		50
Valorga	3.5	1.5	1.4	2.2	6.6	26.3		
VKW	2.5					50		
Wehrle	1.5		6.5*		6			35

Notes: * denotes that the quantity is both paper and plastics

A company left blank indicates that the information provided was insufficient to provide an assessment

This is not a mass balance. Moisture and gas losses, for instance, will also contribute to mass diversion as discussed in Annexe B3.

Source: Process Reviews

What is the demonstrated landfill diversion at existing MBT facilities?

D 2.64. In order for MBT to maximise its landfill diversion potential it must secure an outlet for the primary output it produces. The analysis we have conducted of the information from various operating MBT plants suggests that if markets are secured, MBT can achieve very high landfill diversion on a mass basis. The reported diversion performance of the different processes can range between 80 and 90 percent[1], which would **significantly increase the lifetime of local landfill void space in many regions in the UK**.

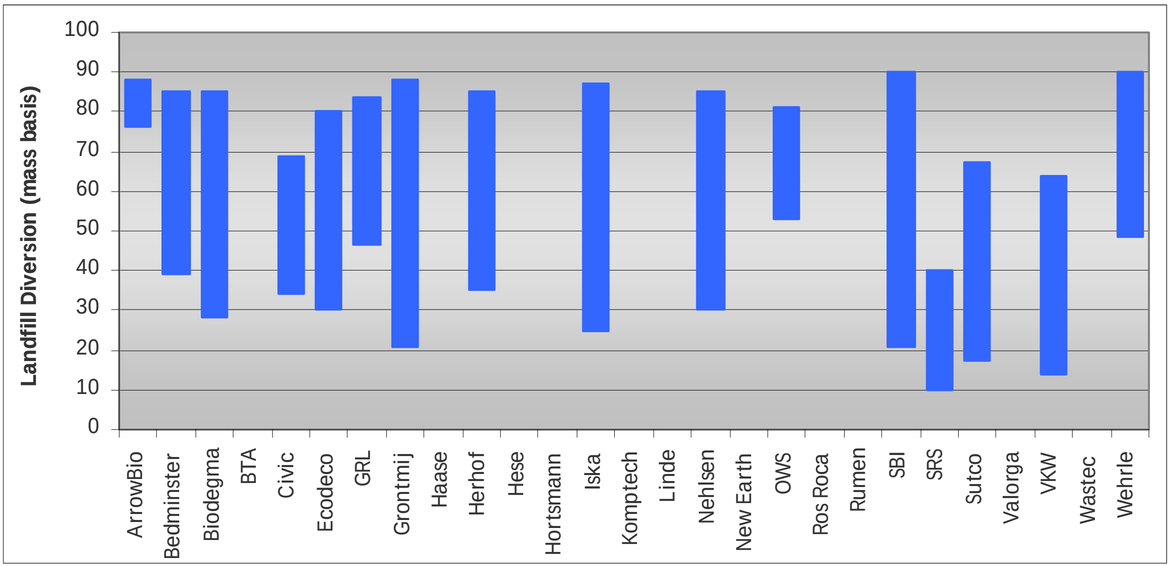
D 2.65. The performance of MBT systems, however, is reduced significantly if markets for the primary output become unavailable; in such cases, the landfill diversion achieved on a mass basis can be as low as 10%.

D 2.66. Because most processes dry the incoming waste to some degree, and at the very least, recover some dense ferrous metals, MBT plants will always achieve at least some

[1] Subject to markets being available for the outputs

landfill diversion on a weight basis. Figure D17 summarises the potential range of landfill diversion performance (on a weight basis) that is achievable by the different processes reviewed in this study.

Figure D17: Typical mass diversion performance of different MBT processes[1,2]



Source: Juniper process reviews

D 2.67. Although achieving a significant diversion rate on a weight basis is an important goal of any waste treatment technology, determining **the amount of BMW that is diverted from landfill** is paramount if operating in the UK. Because of the current uncertainties associated with the outstanding BMW consultation (discussed in the Summary Report and Annexe C) and the different ways certain processes may wish to be configured in a UK context, it could be misleading to provide estimates for different proprietary processes at the present time. We have therefore not provided a comparison of the ability of individual processes to achieve BMW diversion performance here. Rather, a discussion of the important factors which must be considered, including how BMW might be measured in the UK and indicative ranges of BMW diversion that could be expected from different process configurations is presented within Section 11 of the Summary Report and discussed further in Section 3 of Annexe B.

Energy consumption and production

D 2.68. All MBT facilities have an on-going requirement for energy in order to operate the plant. A relatively substantial amount of electricity is required to operate the mechanical components such as shredders, ball mills and/or trommels. In addition to this, certain aerobic processes also will require a substantial amount of energy to facilitate air flow

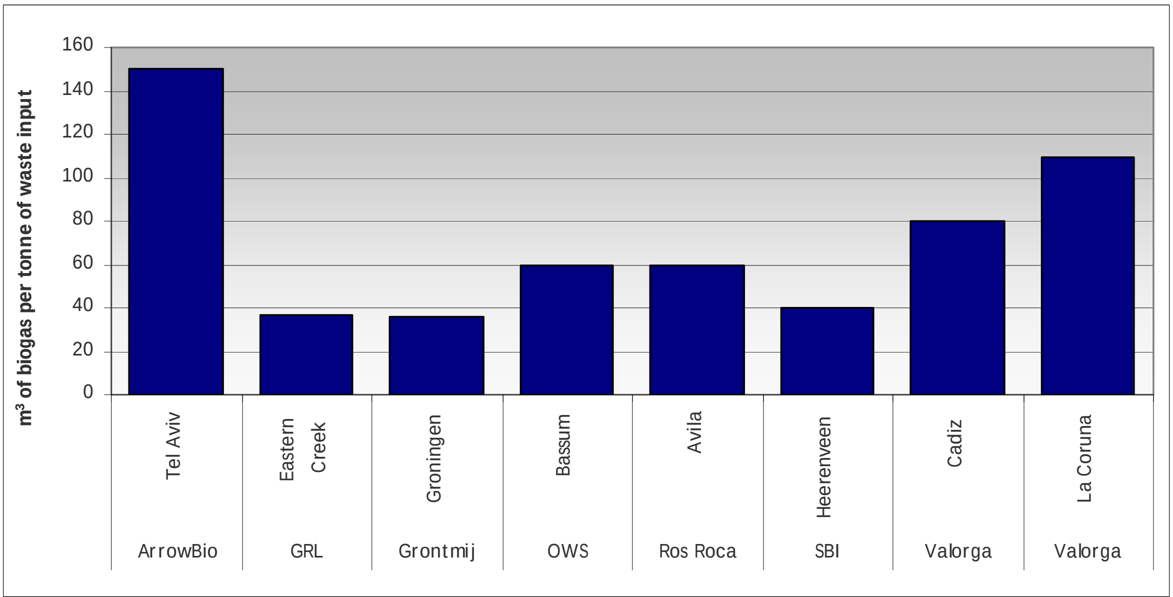
[1] Circumstances may vary, see process reviews for the basis for individual calculations
[2] A company left blank indicates that the information provided was insufficient to provide an assessment

through the reactors. Anaerobic digesters require energy input to enable mixing, to operate pumps and in some cases to maintain the temperature in the reactor.

D 2.69. Unlike for an incinerator or a gasifier, it would be very misleading to define the indicative energy balance of proprietary MBT processes with the aim of portraying a particular process as either net energy positive or negative. This is because, in many particular cases, depending upon the configuration that the process chooses to operate in, it would be possible to be either a net energy producer or consumer. Further information on the energy consumption and production of process suppliers can be found within individual process reviews.

D 2.70. Roughly half of the companies reviewed in this report are promoting a system which has the capability to produce biogas. If used on-site to produce electricity the plant may become net energy positive, i.e. it provides more energy than is needed to meet the plant's internal needs. As electricity produced from biogas is eligible for ROCs in the UK, the sale of electricity can be a substantial source of income for this type of MBT plant.

Figure D18: Production of biogas from selected MBT plants[1,2]



Source: Juniper database

D 2.71. Biogas production and composition varies from process to process and will fluctuate according to the composition of the incoming waste as well as the configuration of the plant i.e. how much of the incoming waste to the plant is processed in the anaerobic digester and the type of AD system used. Figure D18 shows indicative biogas yields per tonne of plant input waste based on information provided by different suppliers. The degree of fluctuation possible from project-to-project is highlighted by the fact that

[1] See process reviews for the relevant assumptions
[2] ArrowBio number reflects the midpoint of the range given

the biogas yields are noticeably different at Cadiz and La Coruña, which both incorporate the same AD technology (supplied by **Valorga)**.

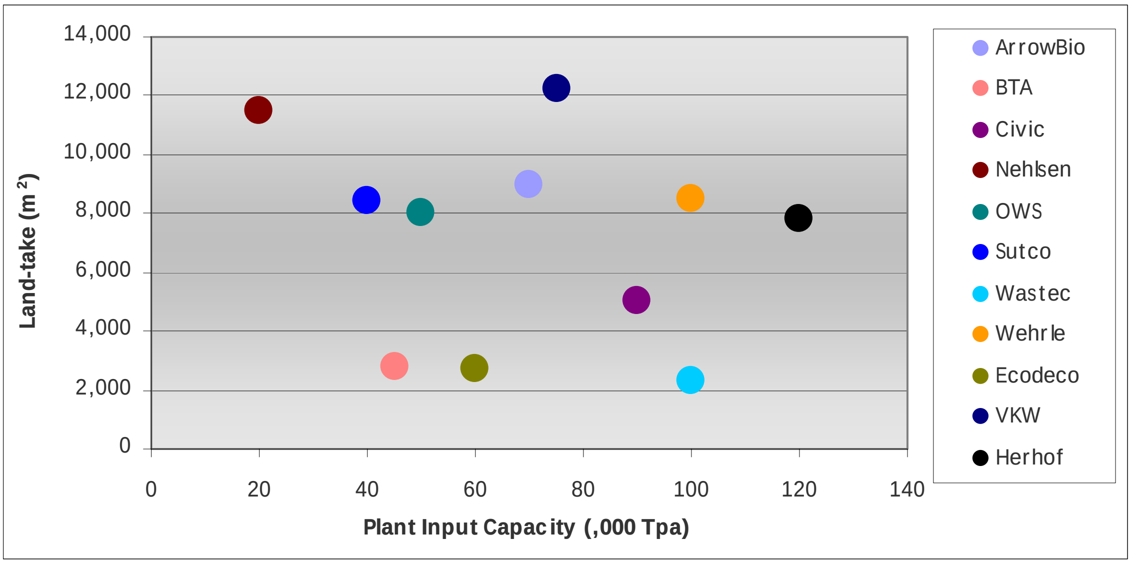
D 2.72. The substantial biogas yield at the **ArrowBio** plant in Tel Aviv, as compared with other processes, is related to the significantly longer period of time that the waste is held within the digester.

D 2.73. If all of the biogas from an MBT plant is combusted, the amount of electricity produced will be significantly less than that produced from a comparably sized waste incinerator. The technical explanation for this is provided within Annexe A.

Land-take

D 2.74. It is self-evident that one of the factors that will influence the overall size of an MBT facility is the volume of waste which it treats. In order to judge whether there was a trend relating to the impact that design capacity had on land-take across all types of MBT processes we have graphed these two parameters in Figure D19. There is no discernable trend in Figure D19 indicating that the factors that determine land-take are many and complex.

Figure D19: Land-take vs. plant capacity[1,2]



Source: Juniper database

D 2.75. One of the most significant impacts on the land-take of an MBT facility is the extent and type of digestion and maturation that takes place. Processes that have longer

[1] This graph excludes the information supplied by Bedminster and GRL because they were extreme outliers. Bedminster's reference plant treating approximately 196,000 Tpa of MSW in Edmonton has a reported land-take of 40,500 m^2. GRL's reference plant in Sydney has a reported land-take of 56,000m^2. The remaining companies did not provide sufficient information for us to evaluate.

[2] See process reviews for the assumptions made about this data

residence times to achieve a greater degree of bio-stabilisation, such as those employing a maturation stage following composting or AD, will have a proportionally slower throughput and thus require larger land space. The amount of ancillary equipment employed for recovering and separating out dry recyclables, and whether hand-picking lines are used, will also affect the overall land-take of a facility.

D 2.76. It is also important to note that the reported land-take values from existing plants in other locations can be misleading. As an example, several facilities located in Germany have been built on a landfill site, and therefore little emphasis has been placed on minimising the land-take of the facility.

D 2.77. Land availability may be more constrained for UK projects. Estimating the site land-take for a particular MBT project needs to be considered on a project-by-project basis. **As a guide, a one hectare site will be sufficient to accommodate a plant treating 100,000 Tpa.**

Costs

D 2.78. Figure D20 lists the capital costs, treatment costs and/or gate fees that were provided by the suppliers reviewed in this report. Many suppliers chose not to provide costs, explaining that they considered such information commercially sensitive or felt that cost derived from a plant operating in a different country would be misleading for UK customers.

D 2.79. We regard this as a reasonable position: in Section 12 of the Summary Report we explain why we also believe that it is not meaningful to compare directly the costs of one reference plant with another. We also caution against comparing 'indicative' costs for individual proprietary MBT systems. The difficulties associated with such comparisons are particularly acute in the case of MBT because the system is so flexible and the configuration used within each project often varies, depending upon the type of input, the goal of the client and the use planned for the bio-treated output. We have concluded that quantitative comparisons should only be made on the basis of a like-for-like' evaluation of responses to a pre-tender, project specific invitation.

D 2.80. Despite this important caveat, we recognised that many process companies do provide indicative costs – in presentations to potential customers for example – and it would be disingenuous not to summarise that information in the context of a wide ranging report of this type, which is why we have provided Figure D20.

D 2.81. Some companies chose to provide indicative gate fees (including profit margin for the operator) and others gave treatment costs.

D 2.82. In our experience from consulting activities, it is generally true that the investment required to build an MBT plant is significantly less than for a similarly sized EfW. It should be cautioned, that this does not necessarily imply that the overall gate fee or treatment cost to a Local Authority will also be lower. The relative capital investment in a facility needs to be considered alongside the costs to operate the plant and the potential revenue or expense to manage the different output streams from the process.

Figure D20: Reported investment and gate fee costs provided by suppliers

Process Company	Reported Plant Cost	Scale (Tpa)	Reported Treatment Cost / Gate Fee
ArrowBio	£7.5M	70,000	**£14-17** / tonne (as operated in Israel)
Bedminster	£44.6 M (cost to build the Edmonton plant as reported in the public domain)	247,640 (193,760 tonnes of input MSW and 53,640 Tpa of Sewage Sludge)	**£31.25 / Tonne**
Biodegma	DNP	200,000	**£46 / tonne** reported for the Neumünster plant including output management costs **£19-22 / tonne** at Pößneck excluding management of the output stream
BTA	c. £1.5M – c.£2.5M for the wet pre-treatment process only	DNP	DNP
Civic	£13-15M	c. 90,000 (6 digesters)	**£ 35-69 / tonne**
Ecodeco	DNP	DNP	Prefer to operate under BOO
GRL	£35-45M (for a 'standard' UR-3R facility)	200,000	**£40-60 / tonne** (Based on a 'standard' UR-3R facility)
Grontmij	DNP	DNP	DNP
Haase	DNP	DNP	DNP
Herhof	DNP	DNP	DNP
Hese	£30M (approx. investment costs of Leicestershire plant being built by Biffa)	112,000	DNP
Horstmann	DNP	DNP	DNP
ISKA	c. £24M for	150,000	**c.£46 / tonne (including the cost of stabilisation but excluding its disposal cost)**
Komptech	DNP	DNP	DNP
Linde	c. £24M (Madrid) Additional data contained within the process review	140,000	DNP
Nehlsen	See process review	See process review	See process review
New Earth	DNP	DNP	DNP
OWS	DNP	DNP	DNP
Ros Roca	DNP	DNP	DNP
Rumen	DNP	DNP	DNP
SBI	c. £25M (approximate cost of Heerenveen plant)	220,000	DNP
SRS	c. £2.5M (approximate cost of Inverboyndie plant)	26,000	**£35-40 / tonne (based on the Inverboyndie plant)**
Sutco	DNP	DNP	**£86, £73 / tonne** (including and excluding landfilling the output respectively)

Valorga	DNP	DNP	DNP
VKW	c. £11M including civils	75,000	See process review
	c. £18M including civils	150,000	
Wastec	£3.3M (four line plant)	100,000 (four lines)	See process review
Wehrle	DNP	DNP	**c. £53 / tonne (based on a German project)**
DNP = did not provide			Source: Process Reviews

D3 The Process Reviews

Background

D 3.1. We have reviewed over 35 different MBT process designs from 27 MBT suppliers.

D 3.2. From February 2004 to December 2004 we visited 28 MBT facilities in 8 different countries (Austria, Belgium, Germany, Israel, Italy, Spain, The Netherlands, UK) and held discussions with suppliers of MBT systems in 2 other countries (Australia, Canada) in connection with this study. The reviews were finalised at dates between October 2004 and February 2005.

D 3.3. The following factors were taken into account when selecting the companies for review:

- Their process(es) has a **biological element** (this excludes so-called mechanical heat treatment systems (MHT)[1] like autoclaving technologies, which share some functional similarities with MBT but do not contain a biological element);
- They have an **integrated** MBT system (a simple composting system with some mechanical sorting are therefore not included);
- Their process(es) have a **demonstrated track record of commercialisation**;
- They are **promoting their process(es) as an MBT solution to local authorities**.

D 3.4. The inclusion of a review for an MBT supplier in this Annexe does not constitute a recommendation as to its performance or suitability. Equally non-inclusion does not imply that that process is not suitable for certain applications.

D 3.5. During preparation of the reviews they were subjected to a 4-member internal peer review panel and a 5-member external Technical Advisory Committee (TAC) to ensure consistency of the information presented and parity between reviews.

What each review contains

D 3.6. Each review has been prepared to a common format. Because of the varying amount of information or the complexity of the process, their lengths vary. The main sections of each review are:

- Summary Page
- Overview
- Status of Technology
- The Process

[1] Annexe A contains a description of MHT processes and provides a list of suppliers who market this type of technology.

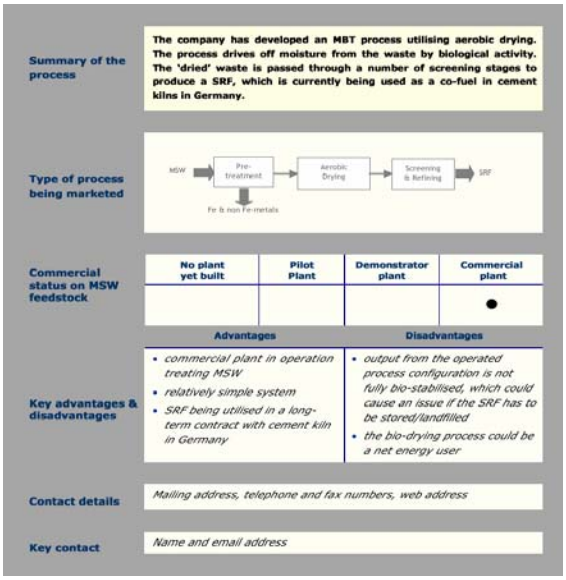
- ⇨ Process Performance
  - Mass balance
  - Energy balance
  - Process availability
  - Landfill diversion
  - Scale-up
  - Process outputs
- ⇨ Process flexibility
- ⇨ Environmental Impact
- ⇨ Visual impact and plant footprint
- ⇨ Cost
- ⇨ Outstanding questions
- ⇨ Summary

Summary Page

The summary page contains the following:

- ⇨ Summary of the process
- ⇨ Type of process being marketed
- ⇨ Commercial status on MSW feedstock
- ⇨ Key advantages and disadvantages
- ⇨ Contact details
- ⇨ Key contact

SAMPLE



D 3.7. **Summary of the process:** is a brief overview of the core stage(s) in the process (mechanical pre- and/or post –treatment, AD, composting, bio-drying) and the main outputs from the process.

D 3.8. **Type of process being marketed:** shows a simplified schematic of the way in which the MBT process is configured and shows where in the process the main outputs are discharged.

D 3.9. **Commercial status on MSW feedstock:** indicates the commercial status of the technology. Where the supplier has at one least commercially operating reference plant a 'dot' is used to indicate this. If the plant is still being commissioned notes are provided under the relevant heading. A more detailed definition of the commercial status of the MBT suppliers we have reviewed in this report can be found in Section 8 of the Summary report.

D 3.10. **Key advantages and disadvantages:** This box highlights key aspects, which are pertinent to managing waste in the UK. **It is not our intention to infer that a process with a greater number of listed disadvantages is inferior to one with less and equally, that a process with a greater number of listed advantages is better than one with less. This is because the advantages and disadvantages relate to a number of different factors: commercial, technical, marketing, environmental and regulatory, which cannot be 'ranked' by simple addition.**

D 3.11. **Contact details:** The name, mailing address, telephone and fax numbers and website address of the supplier are provided.

D 3.12. **Key contact:** The name and email address of the key contact within the supplier's organisation is provided.

Overview

D 3.13. In this section of the process review we present some historical information about the company (including when they started operation, where they originate). We provide details about the current ownership of the technology (including major shareholders), relevant licensees and any UK agents for the MBT supplier.

Status of the Technology

D 3.14. Here we discuss the commercial status of projects undertaken by the supplier.

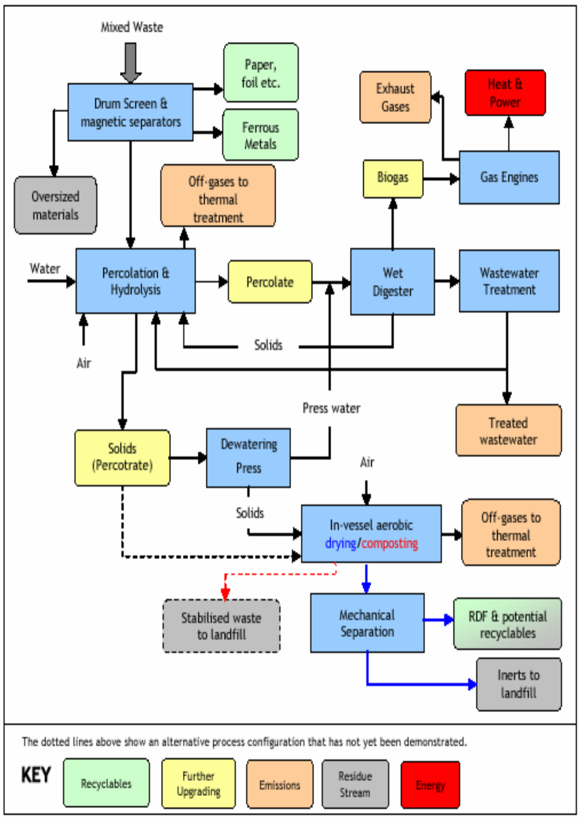
- We provide a reference list, where the information was made available, of the projects completed or planned and indicate where they are located, the headline plant capacity, the capacity of the core biological stage, the current status of the reference plant (i.e. 'operational', 'demonstrator', 'no longer operating' or 'not yet built'), the scope of supply (full turnkey plant or part of the process) and the start-up year.
- In this section we also discuss the supplier's experience with MBT and provide a synopsis of the development history of the MBT process being marketed.
- We have also provided an account of our observations from our site visits to the supplier's reference facility(ies).

The Process

D 3.15. This contains a description of the MBT process including operational information such as process temperature and retention time. In this section of the review, we provide a detailed schematic, which is representative of the MBT process, which includes a standardised colour coding system to represent the various outputs from the process.

KEY for process schematics	
Output is recycled	
Output is recycled. If no markets can be obtained it is landfilled*.	
Output is or must be further upgraded before it is recycled	
Output is an emission that is discharged or sent for further treatment	
Output is a residue stream that is managed by landfilling	
Output is heat and/or power	
Unit operation	
*Dual colour coded boxes are to represent the many variations of this theme.	

Figure D21: Sample of a Process Schematic



Source: Juniper representation of supplier's information

D 3.16. In some cases, the preferred output management route has not yet been established or we believe, from our assessments, that the proposed usage of the output is questionable for UK implementation of the process (such as producing compost from a mixed MSW input to be used on agricultural land). In those cases we have used dual colour coding to show an alternative management route for that output.

D 3.17. In some cases the process described has not yet operated at a reference plant. In those cases the description is for the MBT system that is being promoted in the UK market.

D 3.18. In other cases, a supplier might be marketing more than one type of MBT. Where the supplier has not identified a preferred option for the UK or for its current marketing strategy, we provide a brief synopsis of all the relevant MBT options marketed by that supplier.

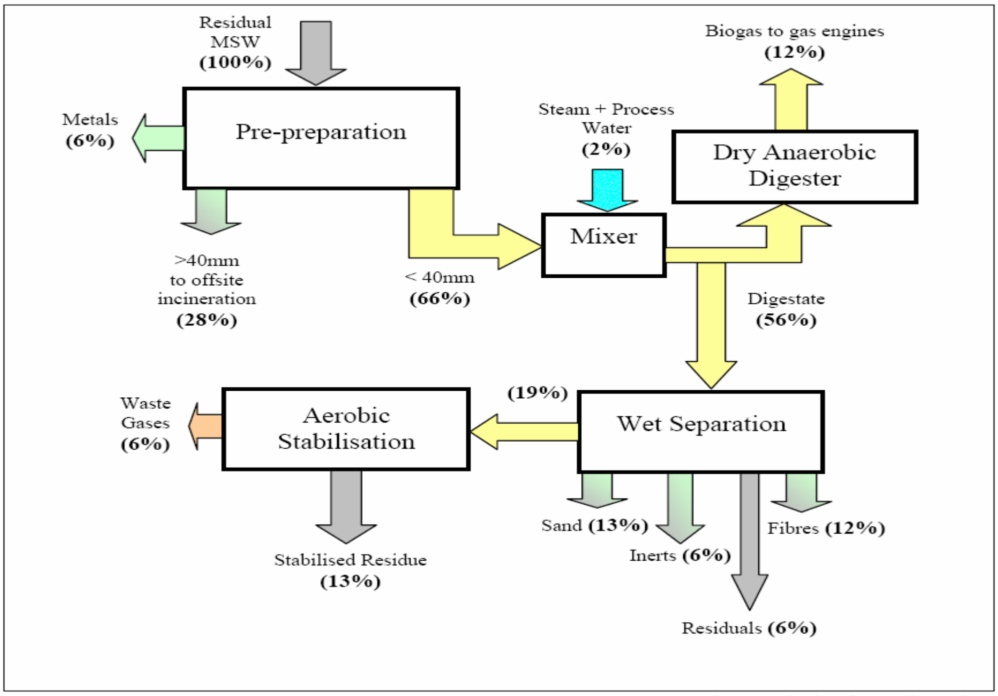
Process Performance

D 3.19. In this section of the process reviews we provide the following information where this has been made available:

D 3.20. **Mass balance:** The data is reported as a weighted percentage based on the waste input to the process. In many cases the mass balance is based on an MBT reference plant. In other cases, the supplier has provided indicative mass balances; we indicate in the caption above the mass balance diagram whether the review is based on real or indicative data.

D 3.21. **Energy balance:** The energy to operate the process and the energy output from the process are shown where relevant information has been provided. We have also calculated, in some cases, the energy that could be generated if the solid fuel output from a process is utilised.

Figure D22: Sample of a mass balance



Source: Juniper analysis of supplier's data

D 3.22. **Process availability:** This parameter measures operational reliability based on the track record of a reference plant. A few suppliers have provided information to indicate how their process has performed since start-up. We have standardised this data to indicate the extent to which the plant has achieved its designed throughput. This type of information was not provided by most of the suppliers we have reviewed and many of them state that because they do not actually operate the reference plant this information is not available to them.

D 3.23. **Landfill diversion:** Based on the mass balance data received we have calculated the total mass diversion from landfill. It is important to note that the process reviews do not give Biodegradable Municipal Waste (BMW) diversion performance against UK LATS targets, because the method(s) to calculate this is still under consultation with the UK Environment Agency. We also do not provide any indicative calculations of BMW diversion based on reference plants that have operated in other geographies because the process companies did not make the relevant information available.

Landfill diversion potential (by mass)

Diversion Potential	Minimum, %	Maximum, %	Basis of Estimation
Percentage of the input waste diverted from landfill	c. 30	c. 80	Min: SRF to landfill, residues to landfill Max: SRF is used for energy recovery, residues to landfill
Note: This is total mass diversion not BMW diversion under UK diversion targets. No data was available on the biodegradability of the process streams.			

Source: Juniper analysis

D 3.24. In our calculation of the total mass diversion, we have used assumptions (referred to as a 'basis of estimation') to determine a **minimum level of diversion** and a **maximum level of diversion**. We have standardised our 'basis of estimation' across all of the processes reviewed as follows:

- ⇨ To calculate the **minimum mass diversion** we have assumed that only metals are recycled from the MBT process.
- ⇨ To calculate the **maximum mass diversion** we have assumed that the main bio-treated output and metals are recycled.

D 3.25. The mass diversion calculated is not meant to reflect the actual capabilities of a specific proprietary process, which may be currently operating at a reference plant in which the total mass diversion performance is higher or lower than those calculated (reflecting the fact that other outputs such as RDF, plastics and glass can be recycled and the fact that metals might not be recovered in the MBT process). The data is meant to show the **'worst case scenario'** if the primary bio-treated output has to be landfilled because of a lack of suitable market outlets and the **'best case scenario'** if all of the bio-treated output were utilised.

D 3.26. **Scale up:** Here we indicate the capacity at which the core process elements have operated. Where appropriate, we discuss whether there are likely to be scale-up issues as a result of plans to build a commercial system that requires the core process elements to treat more waste than the currently demonstrated scale.

D 3.27. **Process outputs:** In this section of the review we quantify all of the outputs from the MBT process based on a plant processing a certain amount of MSW and the mass balance information.

D 3.28. We also briefly discuss the quality of the main outputs: - biogas, CLO, bio-stabilised residues, SRF and RDF - and give data about these where this was made available. For example, where SRF is proposed to be used as a co-fuel, data on the level of contaminants present in the SRF output is provided in the review.

D 3.29. **Process Flexibility:** In some cases, the core systems have been demonstrated in non-MBT applications. In the case of the biological element of the MBT process, some suppliers have gained experience treating various bio-wastes. In other cases, the MBT supplier has experience with the individual mechanical and biological elements of their MBT process. In this part of the process review we provide a brief synopsis of any non-MBT experience that is relevant to designing and implementing the integrated MBT process. In this regard we have provided suppliers' reference lists of non-MBT applications.

D 3.30. Because many of the MBT processes have operated outside the UK on a 'grey bag' or residual waste stream, this section also considers the capability of the process to treat 'black bag' waste.

D 3.31. **Environmental Impact:** In this section of the process review, we have examined the likely impact of the process on air, land and water. Where data was made available we have provided information from operating plants about the quality of the emissions and residues. However, because many of the MBT processes have operated outside the UK, the data reported should not be taken to mean that that process will meet UK environmental standards. However, where the process has operated under EU environmental standards the data can be an indicator of its likely performance in the UK.

D 3.32. **Visual Impact and Plant Footprint:** In this section we have used photographs, mainly taken by Juniper, to show certain aspects of a facility (scale, visual impact, profile, architectural treatment) that we wish to highlight. We also report, in this part of the review, land-take information associated with specific reference plants. But it should be noted that this information can be misleading if considered out of context. In addition, we report the height (in metres) of the tallest element of the MBT process.

D 3.33. **Cost:** Where the company provided information it is summarised in this part of the review. The cost data is reported in Pounds Sterling and Euros where appropriate using a single rate of conversion of £1 (Pound Sterling) = €0.62 (Euros).

D 3.34. Because of the numerous parameters that affect this information, it should only be regarded as indicative.

D 3.35. **Outstanding Questions:** Here we list the information that was requested but not provided by the process supplier. In some cases, the supplier chose not to respond to specific questions because they regarded the information as commercially sensitive. We have drawn attention to these gaps in information because this helps to alert the reader to items that should be explored further with the process company in the context of a specific project.

D 3.36. It is not our intention to infer that a process with a greater number of listed 'outstanding questions' is worse than one with less, or vice-versa.

D 3.37. **Summary:** This is the final part of a process review where we summarise the key strengths of the process and the process supplier. We also identify some of the main challenges and issues that could be faced in implementing the MBT process in the UK.