Costings, mass balances and BMW mass balances for various MBT concepts

Report for:

Milton Keynes Council

Civic Offices

1 Saxon Gate East

Central Milton Keynes

MK9 3HQ

United Kingdom

11th July 2005

ORGANIC RESOURCE AGENCY LTD

Title	**Mass balances, BMW mass balances and costs for various MBT concepts**
Status:	Final Report Revision 1
Date:	12t[h] July 2005
Client	Milton Keynes Council Civic Offices 1 Saxon Gate East Central Milton Keynes MK9 3HQ United Kingdom
ORA Project code	146-05
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Address	Organic Resource Agency Ltd. Malvern Hills Science Park Geraldine Road Malvern Worcestershire WR14 3SZ
Telephone	01684 585423
Facsimile	01684 585422
E-mail	info@o-r-a.co.uk
Author	Dr. Hugh Bulson Dr. Wolfgang Mueller Marcus Niesar M.Sc. Dipl. Ing. Joerg Kaufmann

1 Introduction

ORA was asked by Milton Keynes Council (the Council) to provide data for MBT on the capital and operating costs OF MBT where the waste is stabilised before being sent to landfill. As part of this exercise ORA have determined both the mass balance and the BMW mass balance of the different MBT options. ORA expressed concern that this is normally not the way we like to work because as we have very little background on context in which the information will be used, and the assumptions on which the other options have been developed. However, the Council was eager to get some cost data for use in the options appraisal which will form part of the development of their waste strategy. Because of the very tight time scale ORA was only able to adapt information that was already available from other projects. It should be borne in mind that that the data are both not as specific to the Council circumstances as would normally be the case in ORA's work for its clients.

Three MBT options were developed:

1. Option: "stabilisation"

This option aims to achieve both a high mass reduction and increase an in stability using composting in a table windrow system, with a gantry mounted turning system.

Following discussion with the Council regarding the content of the draft report two sub-options were modelled for the mechanical front-end preparation:

1.1 **"with RDF separation"**: In the front-end mechanical preparation the waste is shredded and screened with 150 mm. The coarse fraction would be used as RDF. The fines fraction (<150 mm) of the screening process is composted in the tunnels. Metals are separated in both waste streams. The retention time for the composting was assumed to be 5 weeks.

1.2 **"without RDF separation**": In this option no RDF is separated, all of the material would be shredded to achieve a particle size which is suitable to allow all of the material to be composted. Metals are separated from the shredded waste prior to the composting. It was assumed that the same facility would be used for this option as for option 1.1. However, to allow for the extra throughput, of the RDF type material, via the composting process the retention time in the composting process would need to be reduced from 5 weeks to 4 weeks.

In both options 1.1 and 1.2 the composting process would be controlled to maintain optimum composting conditions. This requires irrigation, an aeration system to maintain the required temperature (about 55°C) and oxygen levels and a weekly turning to homogenise the material and maintain its structure.

2. Option: "Biological drying"

This option is intended to produce an RDF for energy recovery. The composting process is controlled to dry the material. Typically no water is added to the composting fraction and no turning takes place. The heat produced through the microbiological activity is used to drive off the moisture of the waste to achieve a moisture content of about 15 %. The retention time in the tunnels is reduced to 2 weeks. The dried material can either be used as directly as RDF directly or after it has been subjected to further mechanical separation.

3. Option: Increased recycling and anaerobic digestion

This system is a much more sophisticated one in terms of the technology used at the front end separation in order to separate materials for recycling rather than just to produce an RDF. Furthermore, the biological treatment would include anaerobic digestion (AD) to produce Biogas which is transformed into renewable energy eligible for ROC´s. Some further separation of recyclables (sand, minerals) takes place, which could either be before or after the AD depending on the AD technology used. In this example the separation takes place after the digestion process.

As there are currently only very few options available in the UK for RDF, the impact of landfilling the RDF fraction was assessed in terms of LATS compliance.

2 Comments on the Babtie report

When reading the excerpts provided from the Babtie reports some statements were either not clear or ORA have different opinion which can be summarised as follows:

- The LATS targets presented in table 11 are different from the LATS allocation figures as found on the DEFRA homepage.

- In the explanation of MBT (page 10) it is proposed that the organic fines from the mechanical treatment would be composted in an IVC facility, which also serves the kerbside collected organics. It is not clear whether these two waste streams are mixed before composting or treated separately. ORA´s understanding of MBT is that the organics from the mechanical separation of the MBT should not be composted with kerbside separated organics as the latter could be classified as a PAS100 compliant product and produce a compost for land use, whereas the use of MSW derived compost is very limited especially given the recent changes to the waste exemption criteria.

- The reference Advanced Thermal Treatment (ATT) on page 10 implies that there are lots of options of proven technologies. In our experience this is not the case.

- In the file “Assumptions used for the MBT plants by Babtie.doc” emailed on the 07.07.05 a table shows some assumptions for the BMW calculation. There is no further explanation, but it appears that this calculation was not compliant with the latest understanding of BMW determination (see section 3.3), since moisture loss appears to have been taken fully into account. The Environment Agency has made it very clear that moisture loss, in itself, will not contribute to BMW reduction or BMW diversion.

3 Base data and modelling methods used

As there are few MBT facilities running in the UK there is currently very little information available directly from the UK. Therefore data has been used from facilities on continental Europe, where there are many more facilities from which obtain relevant data

3.1 Waste compositional analysis

The composition of the waste that enters the MBT´s was modelled on data for the Council's waste before introducing recycling schemes and the envisaged recycling rate of 45 % which is the target, as a result of fully developed and introduced all recycling the measures. The key figures can be seen in Table 1.

Table 1: Projected waste compositional analysis of the residual waste

waste composition MKC	**without recycling**	**recyling rates**	**past recycling**
Fractions	%	%	%
Paper/Card	25.0%	68.0%	13.9%
Plastic Film	2.7%	40.0%	2.8%
Dense plastic	3.1%	40.0%	3.2%
Textiles	2.3%		4.0%
Misc. Combustible	18.5%		32.1%
Misc. Non-combustible	2.9%		5.1%
Glass	7.1%	78.0%	2.7%
Ferrous	2.8%	60.0%	1.9%
Non-ferrous	0.9%	60.0%	0.6%
Putrescibles Garden	15.2%	50.0%	13.2%
Putrescibles Food	15.7%	50.0%	13.6%
Fines & others	4.0%		6.9%
Total	100.0%		100.0%
recycling rate			**42.5%**

3.2 Modelling the MBT process and the mass balance

Mechanical treatment

Tests carried out by ORA/IGW at various MBT plants in Germany and the UK have shown that each separation system and conditioning system creates a specific result with respect to the distribution of the material types into the single fractions. It was shown, for example that irrespective of the proportion of kitchen waste in the feedstock (15% - 35%), the drum screening reliably separated the different fractions according to their particle size. The same consistency of separation was achieved with plastics and paper when using air separators or near infrared detection. From the above tests reliable model systems can be developed to sort the materials e.g. dense plastics, plastic film and metals.

The above tests have allowed the development of distribution patterns of the material streams following the application of different combinations of waste treatment systems such as screeners, shredders, grinders, ferrous metal separation, ballistic separation, air separation etc. This knowledge allows the accurate prediction of the mass flow of material streams based on the composition of the raw waste which is processed by the MBT facility.

Biological Treatment

The processes during the biological treatment step have been investigated in extensive large-scale research projects. The relationship between treatment time and the degradation of the organic components has been determined for various technologies both anaerobic digestion and composting both alone and in combination. These data provide a sound basis for modelling the biological treatment process.

Organic matter degradation is primarily determined by the characteristics of the input material. However, it is also influenced by managing and manipulating the early stages of the biological process. The type of technology and how it is managed (temperature, aeration and other control measures) are crucial for this first stage of the process. There are fewer opportunities to do so at later stages where the decomposition and transformation processes are substantially slower during the maturation phase than during the initial intensive composting phase.

Numerous trials and experiments with different composting methods and technologies, either on their own or as a combined process, were carried out in order to obtain the baseline data required for the design and dimensioning of MBT facilities for residual waste. This data has been used in this report.

3.3 Calculation of BMW diversion for MBT

The assessment of the BMW diversion is based on the current knowledge and discussions regarding this issue. ORA has been heavily involved in this discussion and submitted own models which we presented directly to the Environment Agency, at the consultation workshop in Birmingham and various other conferences and workshops.

EA´s response to the MBT consultation paper “Assessing the diversion of biodegradable municipal waste from landfill by mechanical biological treatment and other options” was published at their homepage on the 15-06-05. This paper indicates how EA will assess BMW diversion when treating waste with MBT but does not provide a full protocol how it will work in detail. More details were provided by Terry Coleman (EA) in a presentation at the EA stand at the CIWM show in Torbay; 16-06-05. Conversations immediately after the presentation confirmed ORA’s understanding of how the intends to assess the performance of MBT in determines of the diversion of BMW from landfill.

Given the above the BMW diversion in a MBT will take account of the following:

- Determination of the mass loss in the biological treatment
- Determination of the relative change of dynamic respiration index (DRI) to account for the stabilisation
- Moisture loss is only accounted for to in direct proportion as dry matter mass loss

3.4 Cost calculation

ORA and its partner company IGW have been involved in many MBT projects providing services in all stages leading to the construction and operation of a facility including feasibility studies, preparation of tender documents and their assessment, site management and supervision during construction, commissioning and supervision of the warranty period. From these projects, ORA/IGW have amassed reliable data for all major MBT technologies, mainly in mainland Europe. This data has been adapted to be appropriate for the situation in the UK (especially the higher civils costs in the UK).

The cost calculation includes the determination of the net investment costs, excluding the costs for the site. The operating costs include both the capital element to finance the investment and the costs of operating the plant. These can include staffing, operating supplies (power, water, fuel etc.), disposals (waste water), revenues from the biogas utilisation and maintenance and lifecycle replacements. However, it does not cover the costs/revenues for the outputs (recyclables, disposals), since the assumed levels of costs and revenues which have been used in the other models carried out for the Council were not available to ORA. ORA assumed that the Council would want to keep these assumptions standard across all of the options, thus avoiding any bias, which was not related to the performance of the technology. These cost/revenues will have to be included in final full cost model.

4 Results

4.1 Mass balance and BMW balance

4.1.1 Option 1.1: "5 weeks stabilisation" with RDF separation

Figure 1 shows the process and mass flow diagram for the 5 weeks stabilisation with RDF separation option.

Table 2 shows the results of the modelling.

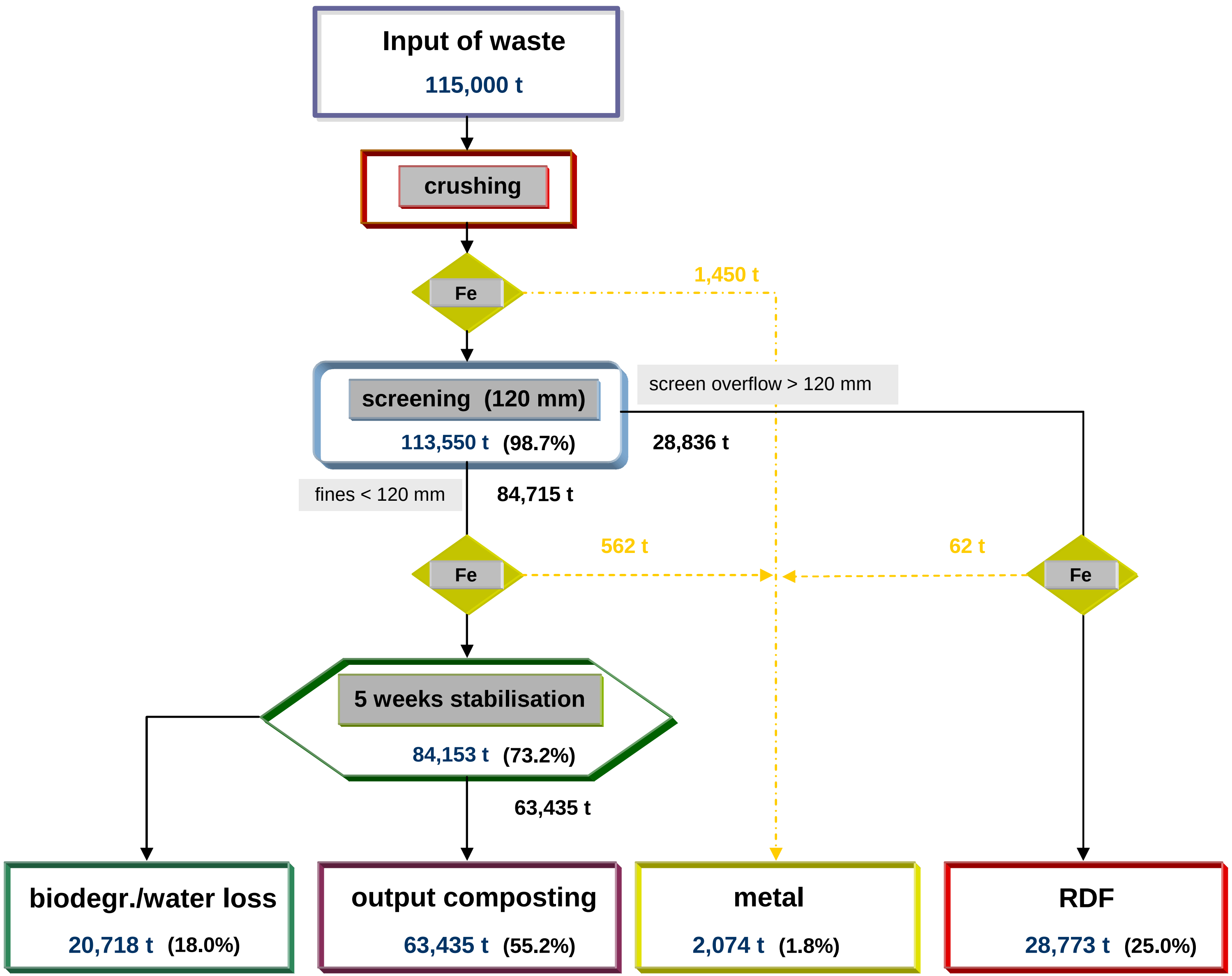

Figure 1: mass balance: option 1 "5 weeks stabilisation" with RDF separation

Table 2: Mass balance / BMW balance for option 1.1 "5 weeks stabilisation" with RDF separation

Mass balance MBT MKC Option 1.1: 5 weeks stabilisation with RDF separation	t/a FM		content BMW %	t/a BMW	% of BMW
Input	**115,000**	100.0%	**59.4%**	**68,260**	
Separation and Sorting					
Fe	2,074	1.8%	0.0%	0	0.0%
Ne	0	0.0%	0.0%	0	0.0%
Total recycling	**2,074**	**1.8%**	**0.0%**	**0**	**0.0%**
RDF (> 120 mm)	**28,773**	**25.0%**	**43.6%**	**12,536**	18.4%
Input composting	84,153	73.2%	66.2%	55,724	81.6%
Output composting	**63,435**	**55.2%**	**59.0%**	**37,406**	**54.8%**
stabilisation factor				**80.0%**	
BMW output composting considering stabilisation				**7,481**	**11.0%**
waste / BMW to landfill					
option 1: RDF goes to landfill	**92,208**	80.2%		**20,017**	**29.3%**
option 2: RDF is utilized	**63,435**	55.2%		**7,481**	**11.0%**
Diversion from landfill					
option 1: RDF goes to landfill	22,792	19.8%		**48,243**	**70.7%**
option 2: RDF is utilized	51,565	44.8%		**60,779**	**89.0%**
biodegradation					
composting					
DM-loss	12,436	23.2%			
oDM loss	12,436	34.1%			
oDMbio loss	12,436	**50.0%**			

If RDF is utilised elsewhere the percentage of BMW to landfill amounts to 11.0 % of input BMW (Diversion 89 %). If the RDF is landfilled as well the percentage of BMW to landfill amounts to 29.3 % (diversion 70.7 %).

4.1.2 Option 1.2: "4 weeks stabilisation" without RDF separation

Figure 2 shows the process and mass flow diagram for the 4 weeks stabilisation without RDF separation option.

Table 3 shows the results of the modelling.

Table 3: Mass balance / BMW balance for option 1.2 "4 weeks stabilisation" without RDF separation

Mass balance MBT MKC **Option 1.2: 4 weeks stabilisation without RDF separation**					
	t/a FM		content BMW %	t/a BMW	% of BMW
Input	**115,000**	100.0%	**59.4%**	**68,260**	
Separation and Sorting					
Fe	2,074	1.8%	0.0%	0	0.0%
Ne	0	0.0%	0.0%	0	0.0%
Total recycling	**2,074**	**1.8%**	**0.0%**	**0**	**0.0%**
RDF (> 120 mm)	**0**	**0.0%**	**0.0%**	**0**	0.0%
Input composting	112,926	98.2%	60.4%	68,260	100.0%
Output composting	**93,864**	**81.6%**	**53.5%**	**50,202**	**73.5%**
stabilisation factor				**70.0%**	
BMW output composting considering stabilisation				**15,061**	**22.1%**
waste / BMW to landfill	**93,864**	81.6%		**15,061**	**22.1%**
Diversion from landfill	21,136	18.4%		**53,200**	**77.9%**
biodegradation					
composting					
DM-loss	12,826	17.4%			
oDM loss	12,826	24.1%			
oDMbio loss	12,826	**40.0%**			

If no RDF separation is included the percentage of BMW to landfill amounts to 22.1 % of input BMW (Diversion 77.9 %).

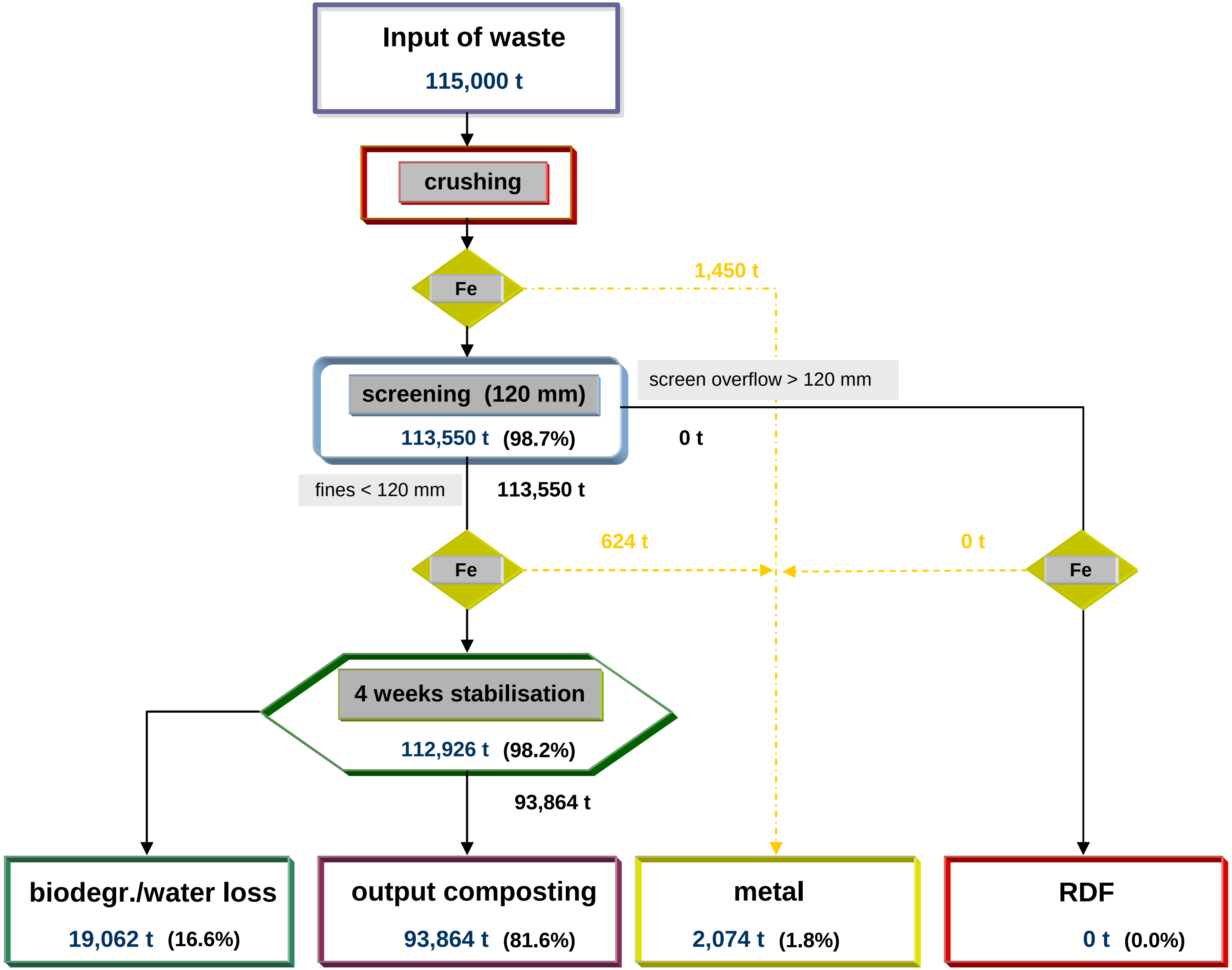

Figure 2: mass balance: option 1.2 "4 weeks stabilisation" without RDF separation

4.1.3 Option 2: “biological drying”

Figure 3 shows the process and mass flow diagram for the biological drying option.

Table 4 shows the results of the modelling of the option 2 MBT biological drying.

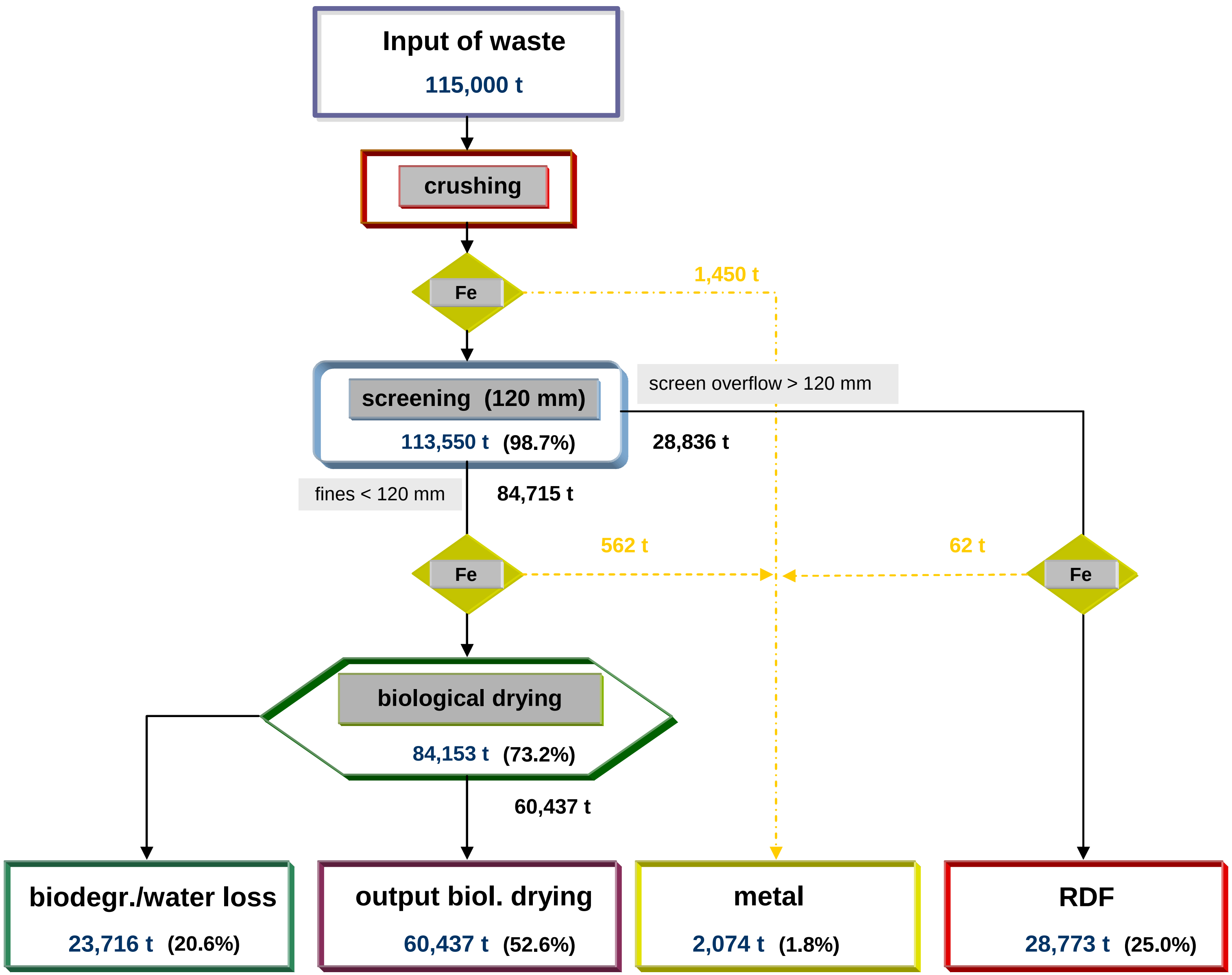

Figure 3: mass balance: option 2 "biological drying"

Table 4: Mass balance / BMW balance for option 2 "biological drying"

Mass balance MBT MKC Option 2: biological drying	t/a FM		content BMW %	t/a BMW	% of BMW
Input	**115,000**	100.0%	**59.4%**	**68,260**	
Separation and Sorting					
Fe	2,074	1.8%	0.0%	0	0.0%
Ne	0	0.0%	0.0%	0	0.0%
Total recycling	**2,074**	**1.8%**	**0.0%**	**0**	**0.0%**
RDF (> 120 mm)	**28,773**	**25.0%**	**43.6%**	**12,536**	18.4%
Input composting	84,153	73.2%	66.2%	55,724	81.6%
Output composting	**60,437**	**52.6%**	**86.2%**	**52,101**	**76.3%**
stabilisation factor				**25.0%**	
BMW output composting considering stabilisation				**39,076**	**57.2%**
waste / BMW to landfill					
option 1: RDF goes to landfill	**89,210**	77.6%		**51,611**	**75.6%**
option 2: RDF is utilized	**60,437**	52.6%		**39,076**	**57.2%**
Diversion from landfill					
option 1: RDF goes to landfill	25,790	22.4%		**16,649**	**24.4%**
option 2: RDF is utilized	54,563	47.4%		**29,185**	**42.8%**
biodegradation					
composting					
DM-loss	2,506	4.6%			
oDM loss	2,506	6.8%			
oDMbio loss	2,506	**10.0%**			

The total mass that goes to landfill (assuming RDF finds a market) is higher for this scenario. The reason is that the moisture content is reduced to 15 % whereas for option 1 it is assumed that moisture content of the landfilled material is 35 %. This is a reasonable figure and appropriate for achieving high compaction in the landfill, thus saving space in the landfill.

Material with a moisture content of 85 % will be very dusty and light and therefore cause problems at the landfill in terms of nuisance caused for the surrounding area (flying plastic and paper) and for the compaction.

If there is a market for RDF then the percentage of BMW to landfill amounts to 57.2 % of input BMW (Diversion 42.8 %). If the RDF is landfilled as well the percentage of BMW to landfill amounts to 75.6 % (diversion 24.4 %).

4.1.4 Option 3: increased recycling and anaerobic digestion

Figure 4 shows the process and mass flow diagram for the 5 weeks stabilisation option.

Table 5 shows the results of the modelling.

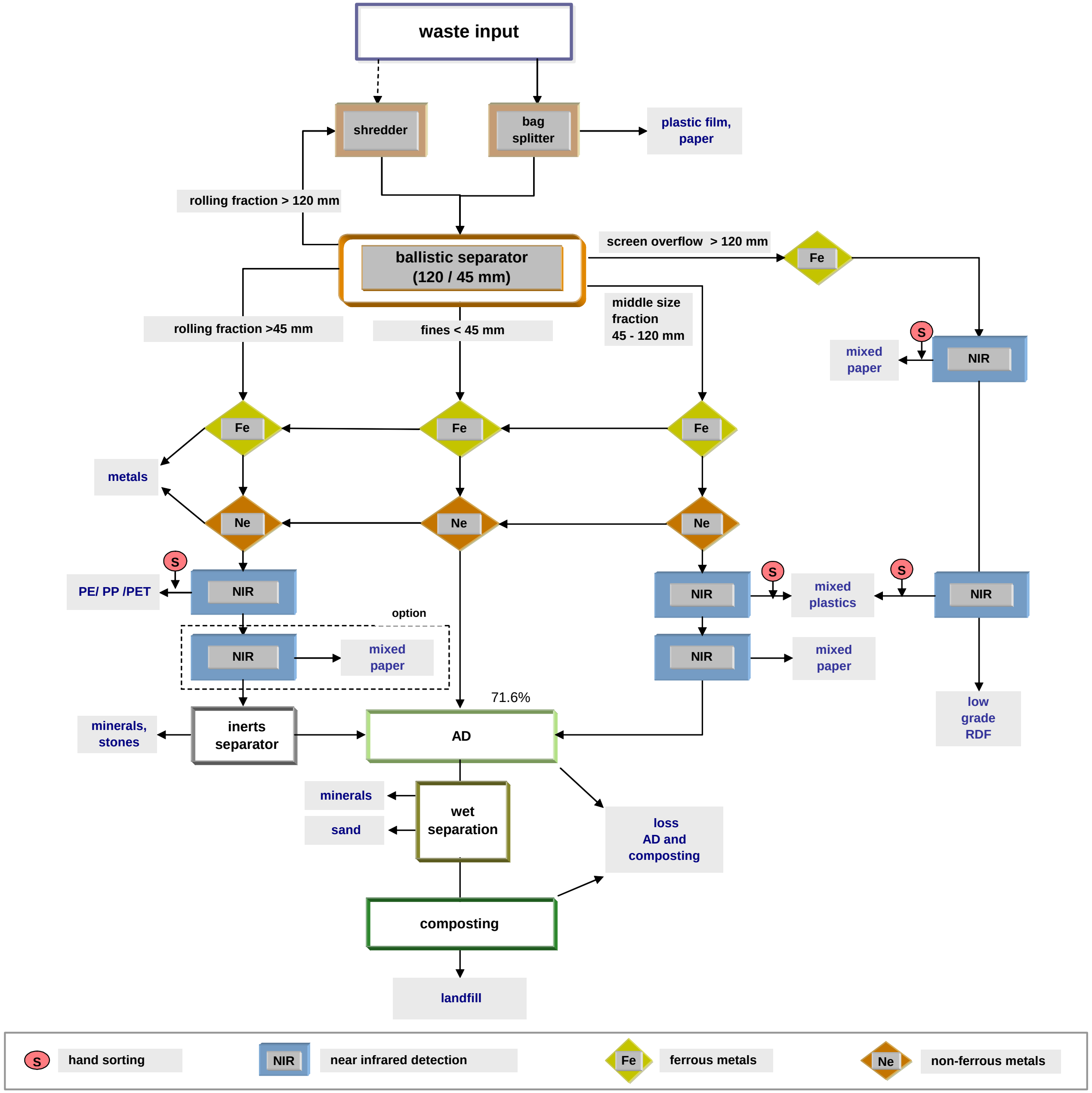

Figure 4: mass balance: option 3 “increased recycling and anaerobic digestion”

Table 5: Mass balance and BMW balance for option 3 "increased recycling and anaerobic digestion"

Mass balance MBT MKC Option 3: increased recycling with AD	t/a FM		content BMW %	t/a BMW	% of BMW
Input	**115,000**	100.0%	**59.4%**	**68,260**	
Separation and Sorting					
bag splitter (RDF)	1,316	1.1%	40.5%	533	0.8%
RDF > 120 mm	18,524	16.1%	51.2%	9,478	13.9%
Paper/Card	3,979	3.5%	100.0%	3,979	5.8%
Fe/Ne	2,301	2.0%	0.0%	0	0.0%
Inerts roling	2,432	2.1%	0.0%	0	0.0%
PE/PP/PET	1,774	1.5%	0.0%	0	0.0%
mixed plastic	2,349	2.0%	0.0%	0	0.0%
Total separation and sorting	**32,675**	**28.4%**	**42.8%**	**13,990**	**20.5%**
Input AD & composting	82,325	71.6%	65.9%	54,270	79.5%
wet separation					
sand / grid	4,939	4.3%	0.3%	15	0.0%
minerals	8,644	7.5%	0.7%	61	0.1%
Output AD & composting	**39,418**	**34.3%**	**66.3%**	**26,150**	**38.3%**
stabilisation factor				**75.0%**	
BMW output composting considering stabilisation				**6,538**	**9.6%**
waste / BMW to landfill					
option 1: RDF goes to landfill	**59,258**	**51.5%**		**16,549**	**24.2%**
option 2: RDF is utilized	**39,418**	**34.3%**		**6,538**	**9.6%**
Diversion from landfill					
option 1: RDF goes to landfill	55,742	48.5%		**51,711**	**75.8%**
option 2: RDF is utilized	75,582	65.7%		**61,723**	**90.4%**
biodegradation					
composting					
DM-loss	15,390	35.7%			
oDM loss	15,390	41.9%			
oDMbio loss	15,390	**65.0%**			

If RDF is utilised elsewhere the percentage of BMW to landfill amounts to 9.6 % of input BMW (Diversion 90.4 %). If the RDF is landfilled as well the percentage of BMW to landfill amounts to 24.2 % (diversion 75.8 %).

4.2 Capital and operational costs

A design of the plant for 115,000 t capacity was developed and priced based on the three options described above. As the major parts of the above technologies come from continental Europe the cost base is in Euros and was converted into British Pounds using an exchange rate of 1.5 £/€. Based on experience from current PFI projects the costs, especially for civils are much higher, in the UK (up to 100 %) compared with continental Europe. This is even more than the statistical increase over the last years (e.g. UK more than 50 % increase, Germany no increase) and is most likely to be due to the lack of experience in the construction of plants and it is likely therefore includes a high allowance for risk. Unfortunately it is nearly impossible to separate the "real" NPV from the type of financing/funding and risk related costs. This applies especially to projects where it is anticipated that there will be a high risk transfer to the contractor. For example in Germany two MBT projects failed because of the attempt to transfer almost all of the risk to the contractor. Because of this the bid price exceeded the Council's expectations by almost 100 %.

The "investment" provides the current price for the whole plant. In capital "Capital costs" the annual refund for this investment is calculated using an interest rate of 7 % (Table 6). Operational costs including all variable costs are summarised: staff, maintenance, supplies and disposals. The "specific treatment cost" shows a break down of the annual costs by the capacity of the plant.

Table 6: Investment and operational costs for the three MBT options

	Option 1 "stabilisation"	Option 2 "biological drying"	Option 3 "increased recycling and AD"
Investment	£18,579,000	£ 17,663,013	£ 36,384,288
Capital costs	£/a 2,139,037	£/a 2,143,034	£/a 4,382,344
Operational costs	£/a 1,437,994	£/a 1,613,765	£/a 2,765,109
Total treatment costs	£/a 3,577,031	£/a 3,756,799	£/a 7,147,453
Specific treatment costs	£/t 31.10	£/t 32.7	£/t 62.2

Please note that this table only provides the treatment cost but does not cover the costs and revenues associated with the solid products which leave the facility. However it does include the revenue for the production power from the generators running on biogas in option 3, albeit with a prudently low price per kw/h.

Option 3 is considerably more expensive than the other two options, which emphasises the point that MBT can come in many different forms and with different costs. The high cost of this particular option is because it is designed to achieve a high recycling rate via very sophisticated mechanical pre and post treatment technology. The AD option also includes a relatively high proportion of civils costs, which as indicated above, are relatively high in the UK. The inclusion of anaerobic digestion will, however, allow option 3 to be scored higher under a lifecycle analysis which could be used as part of a BPEO assessment.