Treatment of the Residual MSW of Leeds City Council – Evaluation of Market Aspects for Treatment Outputs

Final Report (Part 1) to Leeds City Council

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EXECUTIVE SUMMARY

This interim report has examined the status of markets for a number of potential outputs from treatment systems for the residual MSW of Leeds City Council. The market status has been analysed with respect to regulatory and policy aspects, technical issues, commercial issues, and output quality issues.

The risk descriptors for the outputs dealt with are shown in tables ES1 to ES9.

Table ES1. Risk descriptors summary for SRF market issues

Issue / criterion	**Risk**					
	Present			**Future**		
	Power plants / industrial boilers [a]	*Cement kilns*	*Paper & pulp plants*	*Power plants / industrial boilers* [a]	*Cement kilns*	*Paper & pulp plants*
Regulatory and policy	➢ High	➢ Relatively high	➢ Relatively high	➢ High	➢ Relatively high	➢ Relatively high
Technical	➢ High	➢ Relatively low	➢ Relatively low	➢ Relatively high	➢ Relatively low	➢ Relatively low
Commercial	➢ High	➢ Relatively high	➢ Relatively high	➢ High	➢ Relatively high	➢ Relatively high
SRF Quality	➢ High	➢ Relatively low	➢ Relatively high	➢ High	➢ Relatively low	➢ Relatively high

a. Other than paper & pulp manufacturing

Table ES2. Risk descriptors summary for MLU market issues

Issue/criterion	**Risk**	
	Present	**Future**
Regulatory and policy	➢ High (agriculture and pasture land) ➢ Relatively low (low grade uses)	➢ High (agriculture and pasture land) ➢ Relatively low (low grade uses)
Technical	➢ Relatively high	➢ Relatively high
Commercial	➢ High	➢ High
MLU Quality	➢ High	➢ High (because of high uncertainty in its assessment)

Table ES3. Risk descriptors summary for biogas market issues

Issue/criterion	**Risk**	
	Present	**Future**
Regulatory and policy	➢ Low	➢ Low
Technical	➢ Low ➢ Medium (heat market)	➢ Low ➢ Medium (heat market)
Commercial	➢ Low (electricity market) ➢ Medium (vehicles, and public gas network) ➢ Relatively high (heat market)	➢ Low (electricity market) ➢ Medium (vehicles, and public gas network) ➢ Relatively high (heat market)
Quality	➢ Low	➢ Low

Table ES4. Metals (all systems) – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Low	➢ Low
Technical	➢ Low	➢ Low
Commercial	➢ Low	➢ Low
Quality	➢ Low	➢ Low

Table ES5. Paper (MBT) – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Low	➢ Low
Technical	➢ Low	➢ Medium
Commercial	➢ Low	➢ Medium
Quality	➢ Medium	➢ Medium / high

Table ES6. Fibre (AMT) for material recycling – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Medium	➢ Unknown – high
Technical	➢ Medium / high	➢ Unknown – high
Commercial	➢ High	➢ Unknown - high
Quality	➢ Unknown - medium	➢ Unknown – medium

Table ES7. Plastics (MBT) – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Low/medium	➢ Medium
Technical	➢ Low	➢ Low
Commercial	➢ Medium	➢ High
Quality	➢ Medium	➢ High

Table ES8. Plastics (AMT) – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Low/Medium	➢ Medium
Technical	➢ Medium/High	➢ Unknown - medium
Commercial	➢ Unknown –high	➢ Unknown - high
Quality	➢ Unknown - high	➢ Unknown - medium

Table ES9. Inerts / glass – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Low	➢ Low
Technical	➢ Medium	➢ Medium
Commercial	➢ Medium	➢ Medium
Quality	➢ Unknown – medium	➢ Unknown - medium

Not withstanding any potential impacts of the factor local market size, general preliminary conclusions that can be drawn as result of the analysis presented in this report are outlined as follows:

i. Regardless of relative differences in the degree of regulatory and policy inhibition for SRF deployment in power plants, industrial boilers (incl. paper and pulp), and cement kilns, overall it seems that key changes would need to be made in this area to enable the establishment of viable SRF outlets.

ii. MLU is disfavoured by current conditions, particularly as far as higher quality outlets are concerned. Lower quality outlets may be viable provided that the local market size is adequate and markets currently exist with Leeds CC (e.g., parks, gardens) and/or the contractor(s) of the RMSW treatment facility(ies), or there is potential, in terms of size and penetration, for developing other local, low grade markets.

iii. Except for heat and LPG markets, that present some risk, biogas seems to be an output which should be able to find appropriate outlets in the power sector quite easily. Biogas electricity is financially supported through ROCs.

iv. For materials recycling, metals represent the lowest overall risk.

v. Providing the appropriate technology is in place, the situation for single polymer plastics and paper products from MBT is relatively stable although more difficult than the same products derived from source separation schemes. For ATM, the polymer products present more uncertainty regarding quality achievable and markets.

vi. Inert products / glass present similar quality uncertainty but the presence of large potential demand in non-critical low grade civil engineering applications reduces the overall risk. Additionally, disposal to landfill will not count as BMW disposal.

1. Introduction

CalRecovery Europe Ltd has been contracted together with Urban Mines Ltd by Defra (Local Authority Support Unit) to undertake a study on issues pertinent to markets for outputs of treatment systems for the residual MSW (RMSW) of Leeds City Council (Leeds CC), health and environmental impacts of candidate treatment systems, issues of processing of RMSW with other waste streams, and the potential for co-operation with the community/voluntary sector.

This is the first part of the 2-part final report and covers aspects of the status of markets for potential outputs.

2. Methodology

Based on currently available data about the composition of Leeds RMSW and the mechanisms at place for diversion of MSW from landfill in Leeds CC, properties of the RMSW were estimated in order to be able to comment on the potential suitability of generic treatment systems that are commonly applicable to RMSW.

The most suitable of those systems along with the systems preliminary identified by Leeds CC were used as the departure point for the identification of the potential outputs for which markets would be required.

The market status of each of the identified potential outputs, or appropriate groups thereof, was analysed and evaluated by considering regulation and policy, technical, commercial, and quality issues.

The risk associated with each of the issues against which the market status was evaluated has been described using the identifiers: high, relatively high, medium/moderate, relatively low, and low.

3. Composition and Properties of Leeds CC collected RMSW

3.1 Composition of collected RMSW

In summer 2005, a study was undertaken for the characterisation of the residual MSW (RMSW) from Leeds CC and contents of the kerb-side, dry recyclables bin (Jacobs Babtie, 2005). The dry recyclables bin (referred to as “green bin”) is collected on a 4 weekly cycle and targets paper and card, Fe and non-Fe metals, and plastic bottles (PET, HDPE, and LDPE). The results of that study provide compositional data that are relevant to the summer season only, but alternative, recent, annual, average data were not available at the time of writing this report. However, the results are not untypical of past studies in Leeds (Remecom project 1995-97) or similar studies in metropolitan areas.

The data (Table 1) indicate a high degree of contamination in the green bin and other data in the report suggest capture rates are lower than desired. This can occur for schemes at the early stages of their implementation or for established schemes where the degree of on-going maintenance (monitoring, policing, feedback, repeat instructions) has been insufficient to maintain public motivation. This can be a particular problem in areas with high social deprivation and/or mobile populations (e.g. student areas). However given an appropriate time and effort, much higher recognition rates are expected to be achieved and those could impact on waste composition which in turn may influence the properties of the RMSW and green bin contents. Additionally, service provision can be enhanced by increasing collection frequency of the green bin to fortnightly. Glass recycling in Leeds is via bottle banks and is unlikely to change in the short term. Increasing siting density can improve collection rates but a step change in performance would require separate kerbside collection or, if co-collected with the green bin recyclables, a major investment in MRF sorting technology in the locality.

Table 1. Current average composition of Leeds RMSW

Material	RMSW (% wet weight)	Green bin (% wet weight)
Paper and Card	14.30	54.70
Plastic film	4.00	1.80
Dense plastic	5.90	5.90
Textiles	2.70	1.30
Misc. Combustibles	5.40	2.60
Glass	9.10	2.50
Kitchen/Garden waste	49.70	24.00
Fe metals	2.00	1.80
Non-Fe metals	1.20	1.00
WEEE	1.20	0.30
Potential hazardous	0.60	0.10
Misc. Non-combustibles	2.60	3.70
Fines	0.40	0.30
Liquids	0.90	0.00

Table 2 gives the composition of RMSW and green bin contents assuming 100% coverage, ~70% participation rate, and recognition rates for kitchen and for green waste and targeted dry recyclables of 95% and 90%, respectively. The recognition rates for the rest of the waste fractions are assumed to be the same as those observed by the aforementioned characterisation study. The improved, presumed separation of dry recyclables will lead to a diversion of approximately 21% of the collected household waste which is in line with the highest performance levels for dry recyclables schemes implemented in the UK so far (Barton and Papadimitriou, 2004; Entec and Eunomia, 2004). Increased separation would lead to a substantially lower presence of kitchen and garden waste in the green bin while the dense plastic and ferrous and non ferrous metal content of the green bin would increase considerably (Table 2).

Table 2. Composition of Leeds CC RMSW and green bin contents assuming an increased source separation of targeted dry recyclables

Material	RMSW (% wet weight)	Green bin (% wet weight)
Paper and Card	12.94	55.56
Plastic film	4.11	1.62
Dense plastic	3.46	14.84
Textiles	2.18	1.17
Misc. Combustibles	5.55	2.34
Glass	9.35	2.25
Kitchen/Garden waste	54.13	10.42
Fe metals	1.15	4.93
Non-Fe metals	0.68	2.92
WEEE	1.23	0.27
Potential hazardous	0.62	0.09
Misc. Non-combustibles	2.67	3.32
Fines	0.41	0.27
Liquids	0.93	0.00

3.2 Selected properties of collected RMSW

Properties of particular interest regarding options for the treatment of RMSW are its calorific value (CV), moisture content, and the readily biodegradable matter content. The latter indicates the part of the volatile solids (VS) of waste that is readily biodegradable under common conditions for composting and anaerobic digestion and it should not be confused with the term biodegradable municipal waste which covers the whole mass of material that can potentially undergo biodegradation, including its ash content, and that does not distinguish between readily and not readily biodegradable matter. Assuming typical values for CV, moisture content, VS, and readily biodegradable VS for the various fractions of MSW (Barton and Papadimitriou, 2004; CalRecovery Inc., 1993; Haug, 1993), the indicative values for the CV, moisture content and readily biodegradable matter content have been calculated for the Leeds CC RMSW and green bin contents, for both the present and optimised performance of the green bin (Table 3).

Table 3. Selected properties of the RMSW and green bin contents

Waste Fraction	Current RMSW	Current green bin contents	RMSW at improved performance of the green bin	Green bin contents at improved performance
CV (kJ/Kg ww)	9,055	11,426	8,377	13,317
Moisture (% ww)	33	29	35	23
Readily biodegradable matter (as VS -% ww)	22	27	22	23

Perhaps the most important observation is that the assumed improvement in separation of dry recyclables has only a limited impact on the calculated readily biodegradable VS content in RMSW (22% ww). This is not surprising given that the better recognition of kitchen waste and green waste that are kept in RMSW coupled with reduced contents of non-biowaste components such as plastics and metals offsets the better recognition (and loss) for the paper and card to the recyclable bin. According to our calculations, the readily biodegradable matter content is about 70% of that of kitchen and green waste matter which indicates that the Leeds CC RMSW would be a good feedstock for mechanical and biological treatment (MBT) or autoclaving and mechanical treatment (AMT) combined with biological treatment. The moisture content of the RMSW seems to be towards the lower end of the moisture range of RMSW in countries with a longer track record on source separation of MSW like Germany (Plickert and Thrän, 2001). However that will not be a problem as the biodegradable fraction that will undergo biological treatment following mechanical separation has usually an appropriate moisture content. In addition, moisture can easily be corrected by using in-situ resources such as condensate and surface water run-off.

The current CV of RMSW is comparable to that of non-segregated household waste which lies typically in the range of around 8,500 to 10,000 kJ/Kg (ww). The CV of the RMSW assuming an improved performance for the green bin, is lower and accompanied by a slightly higher moisture (Table 3), however both of them remain compatible with treatment by using energy from waste incineration (EfW-I).

Treatment by means of AMT does not impose any technical limitations on CV, readily biodegradable matter or moisture contents. The compatibility of AMT with a particular MSW is primarily governed by the material outputs that are targeted. The current composition of Leeds CC RMSW appears to be compatible with a number of outputs that could find potential uses. Those are BMW, dense plastic, and metals. The changed RMSW composition owing to the assumed improved performance of the green bin will still leave it with a substantial amount of biodegradable matter, primarily kitchen and green waste, while dense plastic and metals will be reduced significantly. However, the remaining BMW might alone justify the use of AMT. Also, glass and film plastic outputs might be targeted too for potential recovery/recycling operations.

With regard to the suitability of the RMSW for treatment by pyrolysis/gasification, although the segregation of paper and dense plastic reduces the substrate available for processing through these routes compared to non-segregated MSW, there is still abundant material of a carbonaceous nature (kitchen, garden, plastic film, and miscellaneous combustibles). In terms of contraries, there are inerts (Fe/non-Fe metals and glass that would, ideally, require removal, but this is common practice with gasification/pyrolysis of MSW.

Summarising, it is apparent that the Leeds CC RMSW should suit the operating envelope of all processes that are commonly considered for the treatment of RMSW; i.e., MBT, EfW-I, AMT, and pyrolysis/gasification.

4. Overview of Treatment Systems and their Potential Products

4.1 General Comments

Based on Information provided by Leeds CC, the options considered by them at present are:

- *"Autoclave + Advanced Thermal Treatment of fibre"*
- *"Autoclave + Landfill"*
- *"Screening + Energy from Waste recovery"*
- *"Mechanical Biological Treatment + Advanced Thermal Treatment of Solid Recovery Fuel + In-Vessel Composting of waste derived compost."*
- *"Mechanical Biological Treatment + In-Vessel Composting of waste derived compost + Landfill of Solid Recovery Fuel"*
- *"Mechanical Treatment + Anaerobic Digestion of waste derived compost and kerbside organics + Landfill of Refuse Derived Fuel"*

It is beyond the scope this project to discuss those options in any detail. However, it may be useful to highlight the following points that might be of potential significance:

a. Autoclaving is considered by Leeds CC only in the context of energy recovery by advanced thermal treatment and as a pre-treatment method prior to landfill. With regard to the former, solid recovered fuels (SRF) may also be used in industrial energy recovery applications considering the properties of the fibre product. With regard to using autoclaving prior to landfilling, it seems difficult to justify such an option given the insignificant capability of autoclaving alone to reduce the content of biodegradable waste.

b. Autoclaving is not considered in the context of combining it with subsequent biological treatment (composting/AD) for the production of an output suitable for land applications. Although under the current waste management licensing regime that may not be easy, this is perhaps one of the greatest strengths that the autoclaving process may posses as far as the treatment of non-segregated MSW or RMSW are concerned.

c. None of the proposed options features MBT employing anaerobic digestion. MBT can feature anaerobic digestion either instead of or in combination with composting, and, as it will be discussed below, given the current regulatory and policy conditions in the UK, AD-MBT may be more attractive than MBT featuring composting alone.

d. The combination of non-segregated, waste-based biodegradable fraction (termed "waste derived compost" in the text provided by Leeds CC) with separately collected BMW seems to nullify the very principle of separate collection for the production of compost for waste licence exempt uses (Anonymous, 2005). In other words, this specific route bears a substantial risk of preventing the output of clean source-separated BMW to qualify as compost under the current regulations.

Without referring to specific systems for delivering the proposed Leeds CC options, the types, quality, and arisings of potential product outputs cannot be adequately specified. Therefore, for the purpose of this project, generally potential types of products and arisings are considered for systems planned around the generic processes of MBT, AMT, EfW-I, gasification and pyrolysis. Quality issues are discussed in relation to specific questions, but owing to the great variation of expected quality, as a result of the variation in system design, provision of specific data on quality is not possible. An overview of the treatment options that were considered by Leeds CC and their potential outputs is provided in Appendix 1.

4.2 Potential types of material products from MBT

There is a range of potential products that MBT systems could deliver depending on the system design. Table 4 gives indicative values for potential outputs/products from MBT of non-segregated MSW/RMSW. These values have been derived by considering newly collated information (Juniper Consultancy Services, 2005) as well as in-house commercial literature.

It should be underlined that the term MLU (material for land use) is used in this report to mean outputs derived from the biodegradable fraction of MSW without source segregation.

Table 4. Potential products from MBT systems

Potential product	Maximum indicative arisings (% MSW input in facility)
MLU (material for land use)	- 15% to 37% for composting MBT
Biogas	60 -110 Nm^3/t input MSW [1]
Fe metals	2% to 5%
Non-Fe metals	0.5% to 1%
Solid recovered fuel (SRF)	- 50% for biodrying processes - 27% to 50% for other types of MBT
Glass cullet	1.5% to 7%
Inerts (without glass)	9% to 13%
Dense plastic	around 1%
Paper	1.5% to 7%

[1]. Fricke and Goedecke (2003).

4.3 Potential types of material products from AMT

The range of potential products of the AMT systems is similar to that of MBT except for that any paper present is turned into so-called fibre. Consideration can be given to using as a substitute for wood/paper fibre in low grade products such as fibreboard, but these markets are not proven. The overall fibre output (i.e., biodegradables, including fines, wood and parts of sanitary and nappies) will still be a biologically active material that may not be appropriate for any land use unless it undergoes further stabilisation by means of composting or AD –presuming that land application is a regulatory legitimate option. In general, autoclaving outputs will have slightly lower moisture content than the typical moisture content of RMSW but, more importantly, this moisture will be more evenly distributed amongst “absorbent” materials. This renders the output more suited to dry mechanical sorting systems aimed at removal of contaminants and product recovery. Table 5 provides indicative values for the arisings of potential products from AMT systems. The arisings’ figures have been obtained from in-house data and commercial literature.

Table 5. Potential products from AMT systems

Potential product	Indicative arisings (% MSW input in facility)
Fibre	53% to 68%
Fe metals	2% to 6%
Non-Fe metals	0.5% to 2%
Glass	1.5% to 7%
Inerts (without glass)	Not available
Dense plastic	Around 1%

4.4 Potential types of material products from EfW-I

Mass burn incineration plant eliminates biodegradable materials and the solid output consists of Air Pollution Control residues (APC) which are hazardous waste along with a bottom ash which has potential for materials recovery. APC residues may be in sludge or fine powder form and although, technically, it is possible to recovery metals such a Lead, Cadmium, and Zinc via hydrometallurgical routes this is not commercial and no UK plants do so. The bottom ash mainly consists of a fine to granular mineral ash (derived from glass, ceramics, masonry, inert fillers in the waste) and metals. Using a mix of crushing / rolling / screening / magnetic and eddy current separation systems, this mixture can yield a low grade aggregate and ferrous and non ferrous metal products. Such systems are commonplace abroad and facilities are now available at or close to new UK EFW-I plants. Materials recovered from EFW-I plants do not count towards local authority recycling targets but the input to the plant does count towards the (non-mandatory) MSW recovery targets. All residues landfilled would be considered non-BMW and hence once RMSW is accepted (and processed) by EFW-I, there is no contribution to an authority's BMW going to landfill.

Table 5. Potential products from EfW-I systems

Potential product	Indicative arisings (% MSW input in facility)
Fe metals	1% (typically 90% recovered)
Non-Fe metals	< 0.5% (50-70% recovered)
Inerts (grit, glass etc)	10 -16% as processed ash product (50 – 80% recovered)

4.5 Potential types of material products from pyrolysis and gasification

Pyrolysis (absence of air) and gasification (sub-stochiometric air/oxygen and/or steam) can potentially produce syngas, oil, tar, carbonaceous char and ash/slag. Syngas and pyrolysis oil could be used in boiler engines and turbines depending on the process conditions and clean-up / refining stages However, most commonly syngas and/or liquids are kept at high temperature and used immediately on-site for the production of electricity and heat while any surplus energy would be exported. Char and pyrolysis slag may be combusted while there is also potential for transforming them into low grade civil engineering materials. As a general point, pyrolysis rarely produces a satisfactory liquid fuel fraction from cellulosic type wastes unless further processed (e.g. hydrogenation) and, if a liquid fuel is wanted, wastes with a high hydrocarbon content (e.g. waste plastics/tyres) are more suitable feedstocks.

Compared to EfW-I, MBT and even AMT (although the latter, until recently, was mainly used for hospital waste treatment) pyrolysis and gasification applications to mixed MSW are new and therefore there is a lack of reliable information about the amounts of potential products. Given that limitation and that neither gasification nor pyrolysis can be considered commercially proven in the context of treatment of MSW, the potential outputs of those systems do not warrant any particular consideration as realistic options. Instead, in this study pyrolysis and gasification will be touched upon peripherally in the context of evaluating issues of SRF.

4.6 Estimation of amounts of potential material products

This section aims to give a rough idea about the arisings of material products that might require a market for the various treatments examined. The calculations have been based on a 2% waste growth rate after 2005/06 (Anonymous, 2003a), and each one of waste sorting sites (civic amenity sites) and drop-off sites diverting 14% and 3% of the total MSW, respectively. Further, a 16% diversion of the total MSW generated has been assumed for the dry recyclables scheme. It is also assumed that the separation efficiency for Fe and non-Fe metals at MBT/AMT plants will be between 60% and 90%, and that MBT or an AMT facility could start operations by 2008 while an EfW-I plant cannot operate at least until 2010.

Table 6. Rough amount estimates for material products from MBT

RMSW/Product	Amount (t/a, or m^3 for biogas)		
	2008	2010	2013
Collected RMSW	255,340	268,260	284,679
MLU	38,310 to 94,475	40,240 to 99,256	42,700 to 105,330
Biogas	13,520,400 to 24,787,400	16,095,600 to 29,508600	17,080,740 to 31,314,690
Fe metals	1,750 to 2,640	1,850 to2,750	1,950 to 2,950
Non-Fe metals	1,050 to 1,550	1,100 to 1,650	1,150 to 1.750
SRF	127,670 [a] 68,940 to 127,670 [b]	134,130 [a] 72,430 to 134,130 [b]	142,340 [a] 76,865 to142,340 [b]
Inert (grit glass etc)	3,830 to 17,875	4,025 to 18,780	4,270 to 19,930
Inerts (excluding separated glass)	Not calculated [c]	Not calculated [c]	Not calculated [c]
Dense plastic	2,555	2,680	2,845
Paper	3,830 to 17,875	4,025 to 18,780	4,270 to 19,930

a. SRF amount from a biodrying MBT system
b. SRF amount from an MBT system other than biodrying
c. Not possible to calculate a reliable indicative value without considering a specific process

Table 7. Rough amount estimates for material products from AMT

RMSW/Product	Amount (t/a)		
	2008	2010	2013
Collected RMSW	255,340	268,260	284,679
Fibre	135,330 to 173,630	142,175 to 182,415	150,880 to 193,580
Fe-metals	1,750 to 2,640	1,850 to2,750	1,950 to 2,950
Non-Fe metals	1,050 to 1,550	1,100 to 1,650	1,150 to 1.750
Glass	3,830 to 17,875	4,025 to 18,780	4,270 to 19,930
Inerts (excluding separated glass)	Not calculated [a]	Not calculated [a]	Not calculated [a]
Dense plastic	2,555	2,680	2,845

d. Not possible to calculate a reliable indicative value without more data about process design

Table 8. Rough amount estimates for material products from EfW-I

RMSW/Product	Amount (t/a)	
	2010	2013
Collected RMSW	268,260	284,679
Fe-metals	2,700	2,850
Non-Fe metals	< 1,350	< 1,400
Inerts (glass, grit etc.)	26,800 -43,000	28.500 – 45,500

5. Market Status for SRF

5.1 General comments

For the purposes of this work, the term SRF has the meaning given to it by the CEN technical committee CEN/TC 343, namely “fuels prepared from non-hazardous waste to be utilised for energy recovery in waste incineration or co-incineration plants regulated under Community environmental legislation”. In the past, terms such as refuse derived or waste derived fuels have been in common use, but clearly, according to this definition SRF encompasses all types of solid waste-based fuels that may be produced by MBT and AMT systems regardless of the type of plant they are used in and whether they are combusted alone or together with other fuels.

Potential outlets for SRF are power stations and industrial production plants (cement kilns and industrial boilers), and dedicated plants for the combustion of SFR. Off-site dedicated facilities were present in the 80’s / early 90’s for densified and shredded refuse derived fuels but do not have a significant commercial presence at the moment (In the UK -Slough Estates is believed to be only site). However, it is feasible to consider an on-site dedicated facility and this has been practiced abroad. The main advantage over mass burn plant is considered to be a reduced capital investment and operational cost in the combustion / use of the SRF but this has to be offset against the production costs. If Leeds CC were to consider a dedicated on-site use of SRF, this would probably extend the timescale for implementation whether prefaced by MBT or AMT plant. For dedicated off-site use, it is not possible to identify an outlet at the present time and a partnership with the user rather than relying on a “merchant” facility becoming available is the only realistic option. Power plants of interest are those that combust solid fuels (typically coal) while production plants include in the first line cement manufacturing, and boilers with co-firing potential such as paper and pulp and the metallurgical industry.

5.2 Policy and regulatory issues – Issues common to all SRF application options

5.2.1 Introductory comments

The best value performance indicator BV82c (energy recovery) applies to the use of SRF as fuel (Anonymous, 2005e).

Currently, there are two potential financial instruments that could have an impact on the costs of using SRF. Those are the renewables obligation order (ROO) (Anonymous, 2002) and the EU trade emissions scheme for the reduction of green house gases (Anonymous, 2003b).

Furthermore, the Government is considering proposals of the Royal Commission on Environmental Pollution for the establishment of a renewable heat obligation (RHO) (Anonymous, 2005b).

The establishment of European standards for SRF is underway by the European organisation for standards (CEN) and the specifications (stage prior to becoming a standard) are expected to be released before the end of 2006. Standards, although voluntary can assist in the establishment of confidence in the industry if they are combined with a quality assurance scheme to ensure compliance and constantly appropriate quality.

The upcoming strategy for waste prevention and recycling (expected towards the end of the year) will be accompanied by proposals for the revision of the waste framework directive. Those proposals will also cover the subject of setting up criteria that would allow us to tell when a waste has ceased being waste and also about what is recycling and recovery (Christopher Allen, European Commission, DG Environment - personal communication, October 2005). This process may take some time to complete, but it seems that it will also address SRF that under the current interpretation of the EU regulations in the UK is waste until it has been transformed into energy.

5.2.2 Best value performance indicator BV82c

BV82c qualifies SRF to count as energy recovery if it is used specifically for the generation of power and/or heat. Furthermore, residues from utilised SRF are biologically inert and will not count towards landfill allowances (Anonymous, 2005d). Thus, from a point of view of landfill allowances scheme (LAS) there is an adequate regulatory incentive for local authorities to produce SRF providing a user is identified (SRF can contain up to the whole amount of BMW present in MSW). However, use of

SRF will only count towards the recovery targets, but not towards any recycling and composting targets. Therefore Leeds CC should consider SRF production within the overall spectrum of statutory obligations that have to be addressed.

5.2.3 Renewables obligation Order (ROO)

The Government is consulting currently for the update of the ROO. According to the current ROO version combustion of SRF could only claim renewable obligation certificates (ROCs) if 98% of its energy content originates from biomass (i.e., biodegradable material). Alternatively, use of liquid or gaseous fuels from the advanced treatment (pyrolysis or gasification) of SRF can claim ROCs for the energy corresponding to the SRF's biomass content. The latter, contrary to electricity from SRF combustion at conventional systems, does not have attached a minimum biomass concentration limit.

The highest content of biomass in SRF currently produced by commercial MBT systems has a value of around 66% (Wangeroth, 2003). A biomass content in SRF of at least 98% is technically and cost-wise a challenging undertaking. A concentration of 80% is believed to be feasible given the current technology status, but this concentration would not qualify for ROCs. Unlike SRF produced from MBT, SRF from AMT systems seems to easily achieve a 90% concentration of biomass (CalRecovery Europe confidential data) and it might be feasible to achieve the 98% threshold much easier than MBT. However, the latter remains to be proved. A 90% biomass concentration threshold has been under consideration with regard to the amendments to the ROO. However the Government is concerned that such a measure may have a negative impact on the ROC price as a result of the increased availability of renewable electricity that may materially impact on the viability of renewable energy plants such as wind-energy which, unlike SRF co-firing plants, depend considerably on ROCs revenue (Anonymous, 2005c). The option of allowing ROCs eligibility for the biomass fraction of SRF that is used at combined heat and power (CHP) facilities seem however to be more positively viewed (Anonymous, 2005c), and in that case SRF may be able to claim ROCs.

With regard to SRF co-firing, which is the only significant potential market for SRF, even if SRF were allowed to claim ROCs, currently there exist limitations regarding the ROCs that can be claimed by co-firing and the SRF amount that is allowed to be co-fired. The latter is essentially constrained by the minimum amount of energy crops that is required to be used at co-firing facilities if these want to be able to claim ROCs. By March 2011, at least 75% of the fuel will have to be energy crops if a co-firing facility wishes to claim ROCs (Table 9). In addition to that, the amount of ROCs that an electricity producer can claim owing to co-firing is limited and will be phased out by 31/3/2016 (Table 9). It is uncertain whether these limitations will be changed in the updated ROO. Given those limitations however, it seems quite unlikely that SRF co-firing for ROCs gain would make any sense, as the time horizon available is extremely short for a profitable production and use of SRF.

Table 9. ROCs that can be claimed from and minimum energy crop percentage for co-firing plants producing electricity

Year (ROCs from co-firing)	ROCs limit from co-firing (% total ROCs)	Year (minimum energy crop co-firing)	Minimum energy crops co-firing for claiming ROCs (% total fuel)
up to 31/3/2011	10%	up to 31/3/2009	25%
up to 31/3/2016	5%	from 31/3/2009	50%
from 31/3/2016	0%	from 31/3/20011	75%

If one assumes that the aforementioned barriers were lifted to allow SRF biomass to claim ROCs, the potential revenue would be substantial (Figure 1). Currently common, biomass-enriched SRF quality, i.e., having a biomass content of 65%, could claim approximately £46/t SRF for ROCs traded on the market (current ROC market value is about £49).

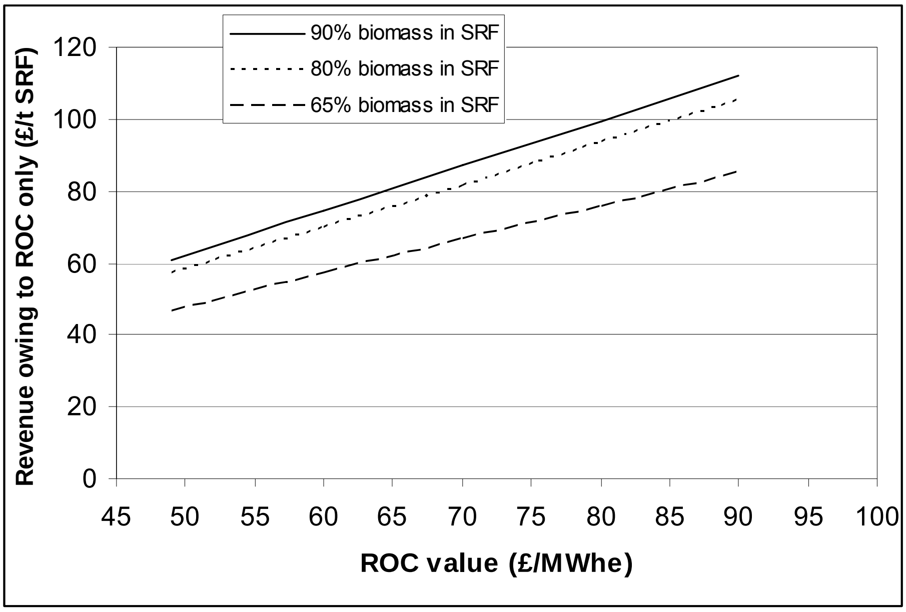

Figure 1. Potential revenue from ROCs if biomass content of SRF were allowed to claim ROCs

5.2.4 The EU trade emissions scheme (EUTES)

EUTES aims at providing mechanisms for the reduction of fossil greenhouse gas emissions in the EU, including in the UK. EUTES has set emission limits for a number industrial installations (including power plants, paper and pulp and cement installations). If an installation cannot comply with the emissions allocated to them they can rectify this situation by undertaking projects to bring about the required emission reduction and/or pay a fine (currently €40 (~£27.5)/t excessive CO_2, but increasing to €60 (~£41.5)//t excessive CO_2 from 2008 to 20012) and/or buy emissions allowances from installations that have cut their emissions below what they are allowed. SFR combustion at any of the designated types of installations would qualify for emission allowances proportionally to its energy owing to its biodegradable matter content (Anonymous, 2003b).

Figure 2 shows the potential revenue from trading emissions allowances in the European market assuming that SRF substitutes coal. The current value of allowance is approximately £5/t CO_2.

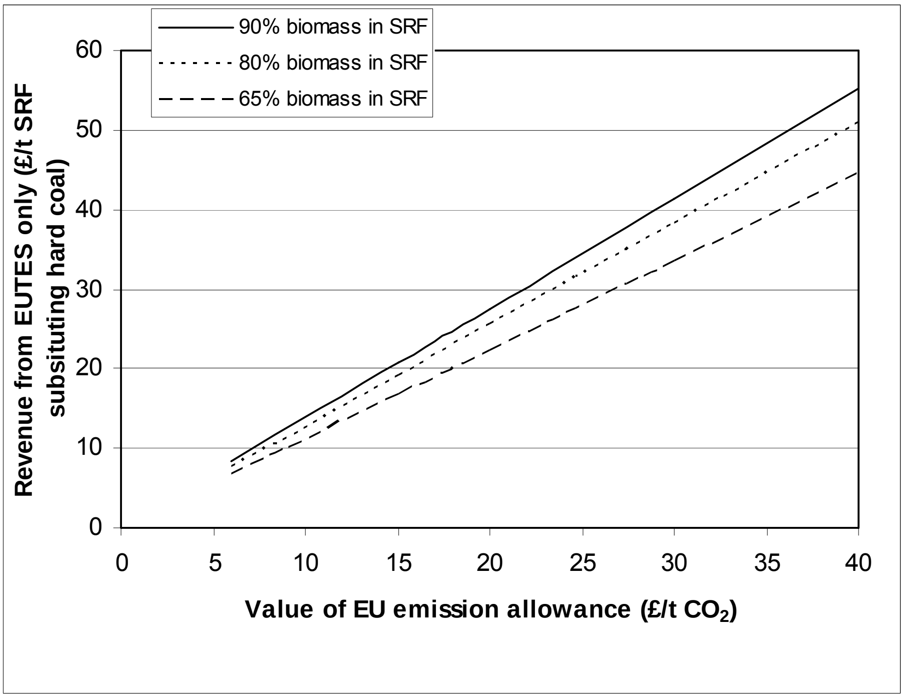

Figure 2. Potential revenue from EUTES assuming that SRF will substitute hard coal

5.2.5 Renewables heat obligation

While there is strong interest in this area it may well be a couple/few of years before a statutory instrument is enacted. There is indeed very little information regarding this issue in the public domain, and one could only speculate about what may be in the Government's proposals. In general, a RHO could provide financial incentives for the use of SRF, including in industrial boiler co-firing that traditionally is used for the production of steam and heat, and for district heat systems. The heat market has been said to be a much more potentially viable market than the electricity market for the use of renewables (Anonymous, 2005b).

5.3 Additional policy and regulatory issues – Use of SRF in power stations

Power stations using brown of hard coal are regulated by the EU Directive on large combustion plants (Anonymous, 2001a). The co-firing of SFR at power stations will mean however that those will come under the regime of waste incineration directive (WID) (Anonymous, 2000) which would mean more strict limits on air emissions; e.g., for SO_2, NO_x and dust than those implied by the large combustion plants directive. Upgrades to air emission control systems for meeting those standards will incur a substantial cost that has to be offset by other monetary benefits to make it attractive for power stations to take on SRF. In general, it is believed that passing on that cost exclusively to MBT/AMT facility operators will not be an option, as this may cause a gate fee that may be prohibitive considering that there are additional changes that should be undertaken at a power plant in order to make it safe and compliant for the co-firing of SRF (see Section 5.5.). A combination of gate fee and financial instruments could, in theory at least, make the required modifications possible. It is not possible to calculate the gate fee that would be required by a power station unless specific data such as station capacity and percentage of fuel substituted by RSF are known. It is however believed that required gate fees may be considerable.

Construction of a dedicated SRF burner on site with the “product” (hot gases / syngas) utilising the heat-recovery and electrical conversion capabilities of the power plant could release the total installation from meeting the WID and may be a more cost effective approach overall. However the site would still need to have a waste management license to accept SRF and the SRF thermal plant would come under WID – the attitude of the Power sector to accepting waste and the inevitable impact and opposition to such facilities tend to engender needs to be established. For most power plants, waste would be a relatively small input and it can be anticipated that there would need to be a significant commercial incentive,

Thus, as discussed, at present, financial instruments do not seem to collectively suffice for the required revenue for the use of SRF. A lot will depend on the amendment of the ROO and a potential RHO.

5.4 Additional policy and regulatory issues – Use of SRF in industrial production plants (cement kilns and boilers)

Both cement kilns and industrial boilers are governed by the PPC regime. However, the cement production sector has adopted a voluntary code/protocol for the use of alternative fuels (Anonymous, 2005g). The latest version of that protocol has lifted a number of barriers that were imposed on SRF use, including the minimum calorific value that used to be 21MJ/kg, and some permit application and licensing conditions. However, as soon as SRF is used at any of those facilities they will automatically fall under the authority of WID which imposes stricter emission controls, although those are more lax regarding particulate and NO_x emissions from cement kilns.

In general because of the nature of the process (very high temperatures in an alkaline environment) cement kilns would not be expected to require any emission control modifications for accepting SRF, and this provides a theoretical potential for the use of SRF in that sector.

Concerning industrial boilers, it is understood that the requirements of WID will require material changes in emission control systems and impose associated financial burdens similar to those for power stations.

An exception might be the paper and pulp industry which, due to voluntary initiatives for the use of non fossil fuel and cost factors, would prefer use to their use de-inking sludge for the recovery of heat and steam (Juniper, 2005). SRF would constitute an ideal material for co-firing with dewatered de-inking sludge at a dedicated plant based in the premises of a paper and pulp facility. Given that paper and pulp plants have steam and boiler facilities and usually have a large foot-print it should not be extremely difficult to acquire a planning permit for an on-site dedicated co-firing facility.

5.5. Regulatory and policy issues for SRF – Summary

Currently, although in terms of LAS and BVPI there are adequate incentives for using SRF, emission control and associated cost owing to WID requirements seem to inhibit the use of SRF in power plants and industrial boilers other than perhaps paper and pulp. Use at cement kilns should also be possible form a regulatory and political point of view. However, current requirements of ROO represent a significant barrier to SRF co-firing in all industry sectors. Hence the risk is believed to be high for power plants and relatively high for all other sectors.

With regard to the medium to longer term, a lot will depend on the changes in ROO, the content and timing of a potential RHO, including their potential associated financial incentives, and the development of the market value of the emission allowances in EUTES. The anticipated ROO is of prime significance in this context, but given that the intentions of the Government seem to be unclear the overall risk for the future are seen as relatively high.

5.6 Technical and commercial issues

5.6.1 Power stations

Power stations in the UK use commonly direct combustion systems. For these systems, beyond the challenges associated with emissions control, there exist a number of additional technical challenges including the following:

- need for installation of an SRF conditioning/handling line at power plant to give SRF the appropriate form and purity that is required for co-firing;
- avoidance of blockages during fuel blending and conveying/feeding into the furnace; and
- corrosion and formation of slag/fouling owing to Cl and K/Na presence in SRF, and erosion of tubes owing to abrasive materials in SRF;

Such issues have been described as being serious by power station operators (Juniper 2005) and would require major re-designing of power stations that of course has a cost and technical challenge attached.

An additional major barrier would be the potential negative impact of SRF on the utilisation of pulverised ash owing to increased heavy metal contents of SRF and the change of other physical/chemical ash properties that are important in its use as civil engineering material –e.g., it will not be allowed to be used in concrete mixtures if it contains biomass ash. The result may be loss of outlets for ash, and this is not welcome at all by operators of power plants.

A potential solution to these barriers might be feasible in the medium term when pyrolysis/gasification technology matures thus enabling the production of SRF syngas that will be co-fired with pulverised coal at power stations (Juniper, 2005; Wangeroth, 2002). However, this option will incur additional monetary cost that would need to be justified.

5.6.2 Cement manufacturing

From a pure technical point of view, there not any major barriers regarding using SRF in cement kilns. Rather, in this sector barriers seem to stem from commercial/market factors.

The substitution levels for a given installation are likely to make the commercial case more attractive than the power sector but such facilities will still need to grasp the nettle of becoming a waste management operation with the higher levels of control and public profile. Such barriers are unlikely to be overcome without significant commercial benefit and a high degree of security of supply negotiated at the outset in partnership with the SRF producer.

Waste fuels from various sectors are already in routine use in cement kilns and, unlike the power sector, can contribute to a much higher proportion of the energy input to a given installation making the commercial case for use a strong one. This is a mixed blessing in terms of SRF, as there will be competition from other SRF based on feedstocks having a higher degree of purity, homogeneity, and calorific value, such as waste oils, meat and bone meal, materials from recycling activities (e.g., car shredding, and WEE recycling), or biomass-based fuels that can claim ROCs -all of these feedstocks can attract good gate fees as there is little effective alternative capacity available.

Although the UK-based cement production as a whole is slightly increased owing to increased construction activities, most of the cement industry is owned by multinational companies that have manufacturing assets in less costly regions of the world and may therefore decide to move manufacturing outside the UK. However given the investment cycle, this is a mainly a longer term consideration though it may impact on decisions to invest additional resources to handle and control MSW-derived SRF's at current sites.

5.6.3 Paper & pulp industry and other industrial boilers

Technical issues regarding co-firing at industrial boilers are expected to be the same as those for power plants. Paper and pulp installations would require the construction of dedicated facilities for the co-combustion of SRF with de-inking sludge and thus should not face the technical challenges faced by power plants/boilers that co-fire pulverised coal with SRF, although they will have to employ costly SO_2 and NO_x removal devices.

Although the paper and pulp plants space and standard heat/energy operations would make it easier to obtain permit for a dedicated SRF-and-de-inking sludge co-firing facility, it is still unlikely they would undertake this type of investment without prior agreement on long term supply from the SRF producer.

Competition with other waste-based fuels is expected to be present in this sector as per the cement kiln sector.

5.6.4 Technical and commercial issues – Summary

At the current point in time technical/commercial issues with regard to employing SRF in power stations and industrial boilers seem to be very inhibiting, mainly due to emissions/product contamination and associated abatement costs. Therefore, the risk in this area is believed to be high.

With regard to future risk, power plants and industrial boilers will be in a more favourable position if indirect combustion (i.e., proceeded by pyrolysis/gasification) is used. There is no particular reason however to believe that this will be the case unless there are economic reasons for doing so which will depend on the regulatory/policy developments. As such the future risk for power plants and industrial boilers may be said to remain relatively high.

Although coming under the WID requirements, the technical risk for the cement industry is relatively low owing to the process conditions. Commercial risks are seen as high though owing to competition with other substitute fuels and the uncertainty regarding the future production of cement in the UK.

The paper and plant industry seem to be affected by relatively less adverse technical issues. However, commercial parameters include competition with other waste-based fuels, and the need to finance dedicated plants for the co-combustion with de-inking sludge. The technical/commercial risk in this area is therefore seen as relatively high both for the present and future unless significant progress is made to overcome the type of barriers identified by the Biomass Task Force and others.

5.7 Quality issues

There is very limited reliable information regarding the quality of MSW-derived SRF produced by MBT/AMT. This has not helped building confidence in the market. Issues relative to quality have already been outlined as part of the technical issues and it is apparent that there are a number of concerns regarding the common quality of SRF that is to be used in power plants or industrial boilers.

Specifically regarding paper and pulp plants and the co-firing of de-inking plants and SRF at dedicated plants does not seem to be as negatively affected by quality issues as power stations, since dedicated facilities will be designed to deal wish such issues. However, lack of track record on SRF utilisation in such facilities indicates that risk may be relatively high.

Quality with regard to using SRF in cement manufacturing is not a significant issue in terms of the typical contaminants associated with SRF and the main concern will relate to costs and calorific value. Low calorific value SRF could reduce temperatures and calcining capacity of the kiln and effect production rates. However, the overall lack of data and limited track record for quality parameters do impose general uncertainties.

The re-approaching of the issue of SRF production primarily by MBT technology providers, but also by AMT system providers and operators of plants, in conjunction with the introduction of quality standards for MSW-derived SRF and accredited quality assurance systems (e.g., in the Netherlands and Germany) mean that SRF quality would have to satisfy the specifications to be deemed acceptable. CEN have been working on the establishment of specifications for SRF, including MSW-derived SRF, and those are expected to be released soon. However, the process for their recognition as standards will take sometime, whilst the industry in the UK needs rather accelerated improvements to overcome uncertainties regarding SRF quality. It is nonetheless difficult to see material changes taking place in the immediate future. Hence, the overall risk regarding quality seems to be relatively high for both the present time and the future.

5.8 SRF market risk – Summary

Table 10 gives an overview of the estimated current and future risk level for the SRF market for the criteria/issues examined.

Table 10. Risk descriptors summary for SRF market issues

Issue / criterion	**Risk**					
	Present			**Future**		
	Power plants / industrial boilers [a]	*Cement kilns*	*Paper & pulp plants*	*Power plants / industrial boilers* [a]	*Cement kilns*	*Paper & pulp plants*
Regulatory and policy	➢ High	➢ Relatively high	➢ Relatively high	➢ High	➢ Relatively high	➢ Relatively high
Technical	➢ High	➢ Relatively low	➢ Relatively low	➢ Relatively high	➢ Relatively low	➢ Relatively low
Commercial	➢ High	➢ Relatively high	➢ Relatively high	➢ High	➢ Relatively high	➢ Relatively high
SRF Quality	➢ High	➢ Relatively low	➢ Relatively high	➢ High	➢ Relatively low	➢ Relatively high

a. Other than paper & pulp manufacturing

6. Market Status for MLU

6.1 Policy and regulatory issues

MLU can count towards BV82b (composting) if it is stabilised and sanitised, is rich in humic substances and can be used as a soil improver, as ingredient in growing media or blended with soil to produce top soil that will meet the British Standard BS 2882. It should be noted that if AD is used as part of an MBT facility or combined with an AMT system treating RMSW, the output does not need to be stabilised or be rich in humic substances.

In a hypothetical case of using RMSW to produce MLU that satisfies the aforementioned conditions the proportion of RMSW that is input to biological treatment will count towards BV82b. In reality however, the critical factor is the qualification of MLU as a soil improver, ingredient for growing media or top soil.

There is not a statutory definition of soil improver/growing medium in the context of waste-based products in the UK. The PAS100:2005 specification, which is a non-statutory specification, uses the definitions of the EU eco-label Decision for soil improvers and growing media (Anonymous, 2001). Those definitions are general and quantitative limits for the characteristics of such materials are not given outside the eco-label context. Besides, PAS100:2005 applies to compost produced from separately collected BMW, and it can not certify MBT/AMT MLU even if that satisfies the limits set by PAS100:2005.

With regard to potential qualification of MLU as "general purpose" or "economy" grade top soil following mixture with soil, although UK BS2882 requires only that the heavy metals content should not be "at undesirable concentrations", it also necessitates that upon visual inspection those two grades of top soil are free of contrary material (e.g., glass, plastic, metals, rubble etc). Given that even as much as 1% (dry weight) of foreign matter content could cause visual intrusion, it might be difficult to achieve the requirements of BS2882. Another point of concern is the permitted extent (if at all) for mixing of soil and MLU.

Some light regarding the suitability of RMSW MLU for land applications provide the recently amended waste management licensing regulations (Anonymous, 2005a). Under those regulations BMW-derived materials for use on agricultural or pasture land (Para 7A) can only be exempt from waste licensing if source segregated BMW has been used for their production. MLU based on non-separately collected BMW could only be exempt for land restoration/reclamation uses, including landfill restoration, under Para 9A of waste management licensing regulations. Necessary condition in both cases is that material for land applications brings about agricultural or ecological improvement at no adverse human health or environmental impact. On the other hand, a recent guide issued by the Environment Agency states that if an operator proves that spreading of MBT MLU on land results into agricultural or ecological benefit without negative impacts on health/environment it could be exempt from waste licensing (Anonymous, 2005d).

Based on CalRecovery's experience, there are indications that the EA would examine the qualification of MLU for land spreading (e.g., in agriculture) on a case by case basis without ruling it automatically out on the basis of its RMSW origin. In the past sewage sludge has been used as the point of reference for judging MLU's qualification, but there is no guarantee that the same will happen in the future. Based on the above the degree of uncertainty regarding spreading of MLU on agricultural/pasture land is currently high.

The situation is quite straight forward with regard to the qualification of MLU for land remediation, landfill restoration, or landfill engineering material (excluding as cover though). All of these low grade outlets have a chance to count as recovery, and in this case their BMW content may not count against landfill allowances. The classification as recovery will have to be decided separately for each case, and it requires as a minimum the replacement of natural resources (Anonymous, 2005d). These conditions make MLU use for lower grade land/landfill uses a rather relatively low risk option from a regulatory/policy point of view at the current point in time.

The EU strategy for the prevention of waste and recycling and its accompanying proposals for the amendment of the waste framework directive intend to also cover technical criteria for compost materials (and perhaps MLU) that, along with other factors, might allow them to be classed as non waste. Although, it may take at least a couple of years for such standards to be agreed upon, they are expected to have a decisive impact on the potential for spreading of MLU on land.

6.2 Quality issues

Perhaps one of the most significant barriers for developing markets for MLU is its past history. Back in the 80's and early 90's attempts to produce compost from non segregated MSW were not successful, and the legacy of those attempts haunt MLU's reputation to date although in the meantime technological developments have made possible in some cases to produce MLU that can satisfy compost standards.

For example MBT systems that have shown good performance in that sense have been reported by de Baere and Boelens (1999) and Juniper (2005). However, those cases are just a few, and some of the quality parameters of concern such as Cd and Hg are very close or even just above threshold values. Also, data, including commercial operation data that demonstrate the capabilities of MBT systems do not seem to exist in the public domain. This is not surprising if one considers that MBT was originally developed not for the production of compost but for the pre-treatment of MSW intended to be landfilled. Performance depends a lot on both the design of an MBT system as well as the quality of MSW being fed to it. Without considering a specific design in relation to a specific MSW feedstock any further commentary on this issue would not be accurate.

Similar is the situation with regard to MLU produced by AMT systems, and the main barriers are again lack of reliable information from R&D work or operational experiences over an adequate time span with full scale systems. CalRecovery Europe have in the past conducted work in this area that has confirmed that situation. We are also currently participating in project funded by Defra dealing with MSW autoclaving for the production of high quality MLU (compost). Preliminary results are encouraging, but time is required for the drawing of founded conclusions.

Overall, both MBT and AMT seem to be currently carrying a relatively high risk regarding quality. The risk regarding the future cannot be commented upon assessed based current data.

6.3 Technical issues

Technical issues related to the production of MLU are associated with the separation of foreign material and material that can release contaminants in the MLU such as heavy metals and synthetic organic compounds. Size reduction is mostly associated with release of pollutants into the BMW fraction at MBT processes while autoclaving is the unit process that affects the release of pollutants in AMT facilities. MBT employs chiefly dry separation methods; however wet separation methods (i.e., using water to separate BMW from other fractions) are also used, although to lesser extent. AMT systems typically use dry separation systems. Based on the quality issues addressed above there are currently technical issues that render uncertain the quality of MLU. Future advances in MBT/AMT treatment capabilities are in general to be expected as new R&D work and experiences with existing systems are evolving. However, any opinions on this matter at present would be purely speculative. This information points toward a relatively high risk regarding technical issues

6.4 Commercial issues

If aimed for agricultural purposes/pasture land, MLU will have to compete with composts from source separated MBW. Although to date for various reasons the industry has been sceptical about source separation of BMW and have been looking at alternatives, the target years for the fulfilment of BMW diversion targets are imminent and the industry have to build facilities. Given that source separation of BMW provides relatively increased certainty in relation to compost quality, it would not be surprising if a substantial part of the industry chooses this route. With a quality assurance system for composts already in place in the UK, albeit voluntary, and generally markets for compost still struggling to develop, it may be difficult for MLU to compete against compost. This situation is not in general expected to change in the medium term.

6.5 MLU market risk – Summary

Table 11 gives an overview of the estimated current and future risk level for the MLU market for the criteria/issues examined.

Table 11. Risk descriptors summary for MLU market issues

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ High (agriculture and pasture land) ➢ Relatively low (low grade uses)	➢ High (agriculture and pasture land) ➢ Relatively low (low grade uses)
Technical	➢ Relatively high	➢ Relatively high
Commercial	➢ High	➢ High
MLU Quality	➢ High	➢ High (because of high uncertainty in its assessment)

7. Market Status for Biogas

7.1 Policy and regulatory issues

The input of AD processes can count towards BV82c if those processes are not aiming to stabilise organic substrates and the digestate has not a quality appropriate as a soil improver, growing medium ingredient or ingredient for the manufacturing of top soil according to BS2882, and if biogas is produced. Whether the actual use of biogas is necessary for the allocation of credits for BV82c is not clear, but it would be very surprising if methane flaring off would count as “energy recovery”.

The ROO entitles the non fossil energy produced from gaseous fuels derived from AD processes to gaining ROCs. Since AD gaseous fuel (biogas) is entirely derived from the decomposition of biomass, electricity produced by using biogas can claim ROCs. This is currently a major advantage over SRF.

Assuming typical biogas properties, the potential revenue from biogas ROCs could be a considerable source of income for facilities using anaerobic digestion to treat RMSW having high BMW levels like that of Leeds CC (Figure 3).

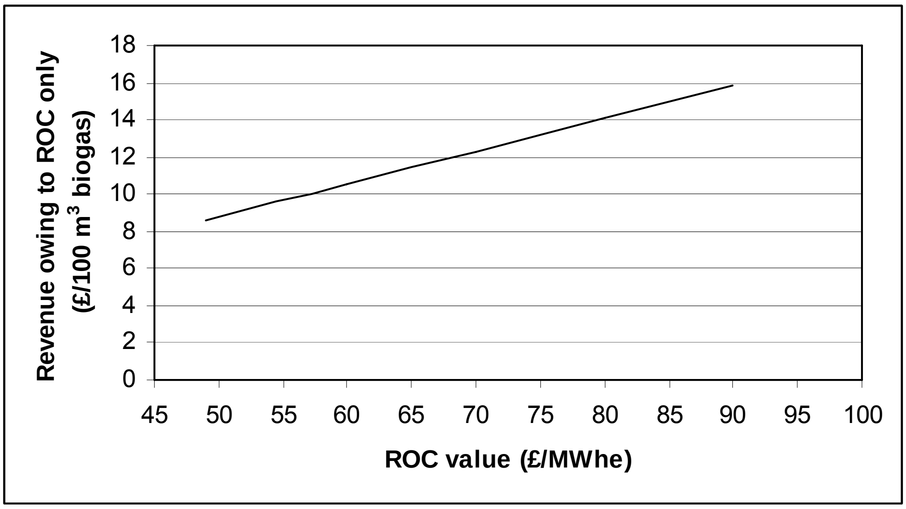

Figure 3. Potential revenue from ROCs claimed through biogas-derived electricity

In addition to ROCs biogas can gain income from its direct use at or supply of electricity to installations regulated by the European Trading (green house) Emissions Scheme. Figure 4 shows the estimated potential revenue owing to EUTES based on the assumption that biogas energy is used to substitute that of hard coal. Similar to the EUTES revenues for SRF, EUTES *per se* does not seem to represent an adequate incentive for the deployment of biogas energy by the designated industrial installations. However, EUTES is enforcing the potential impact that ROCs may have on biogas production form RMSW.

Overall it can be inferred that the current regulatory climate favours the production of biogas from RMSW and as such this material appears to be of low risk.

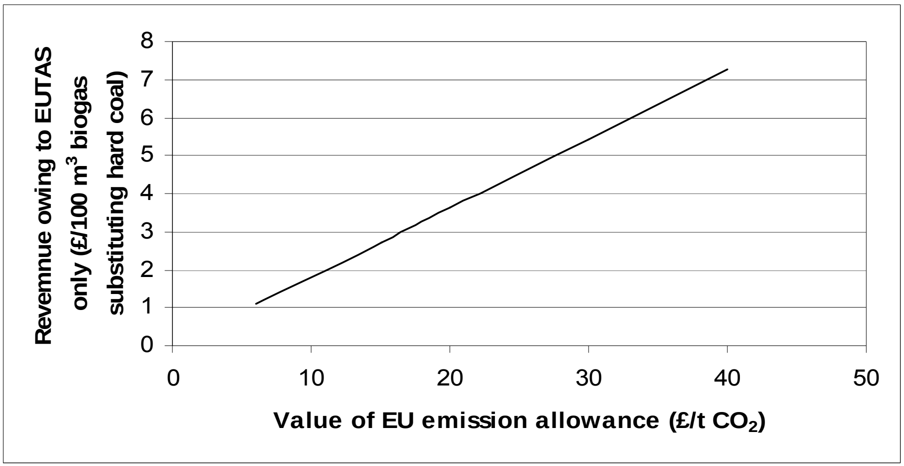

Figure 4. Potential revenue from EUTES assuming that biogas will substitute hard coal

7.2 Quality issues

Biogas quality is practically not affected by the fact that is derived from RMSW. Its quality is compatible with electricity generators or combined heat and power units, and there is a long track record of successful combustion of biogas in such units. The same apply to using biogas as a vehicle fuel or feeding it to the public gas network. As such the risk in this area is considered to be low.

7.3 Technical issues

Biogas can easily be used in-situ to produce electricity that can subsequently be fed the grid. Heat recovery is usually practiced in order to cover internal heat demand of RMSW treatment facilities but it could also be used for district heating purposes. Systems for upgrading or conditioning the biogas for use as a vehicle fuel or to a standard that could enable introduction into the natural gas network are also available. All of these processes are proven and do not pose any risks.

7.4 Commercial issues

In general the market is considered to be mature and stable as far as electricity from biogas is concerned and given the current climate, there are not any important competitors for biogas. Syngas from gasification/pyrolysis may be competitors for biogas, but given the commercial status of those two technology options it will take some time until competition might materialise.

While uses biogas as vehicle fuel or in the public gas network are less likely to be the options of first choice due to additional technical complexity and less certainty with regard to commercial status, they do provide additional security / alternatives to on-site use. Biogas conversion to a vehicle fuel may be attractive where there is local “in-house” demand from the municipal transport activities (e.g. buses, refuse vehicles).

Commercial issues are therefore considered to be minimal or of low risk regarding biogas electricity markets, and relatively low regarding the production of LPG for vehicles and feeding into public gas network.

Use of biogas-derived heat would require heat production to be close to its market. Although modern AD facilities may be within urban or commercial areas, negative perceptions and associated monetary costs for odour control measures mean that it is likely that an AD facility would not be located close to residential or commercial heat outlets which would mean that heat export may not be affordable given that retrofitting of existing district heating systems may be a costly operation. Heat export may however be easier to be practiced at nearby industrial installations. However almost invariably this will invariably require some additional infrastructure for the delivery of the heat that would add to the cost of heat production making it in general less attractive. Thus heat use from biogas is perceived to be an activity associated with relatively high risk at the current point in time. With regard to the future, if a RHO were to be introduced it would be expected to support biogas heat too, and this would help to offset the current commercial drawbacks to some extent. Hence it is felt that future risk in this area can vary between relatively high to relatively low.

7.5 Biogas market risk – Summary

Table 12 gives an overview of the estimated current and future risk level for the biogas market for the criteria/issues examined.

Table 12. Risk descriptors summary for biogas market issues

Issue/criterion	Risk	
	Present	**Future**
Regulatory and policy	➢ Low	➢ Low
Technical	➢ Low ➢ Medium (heat market)	➢ Low ➢ Medium (heat market)
Commercial	➢ Low (electricity market) ➢ Medium (vehicles, and public gas network) ➢ Relatively high (heat market)	➢ Low (electricity market) ➢ Medium (vehicles, and public gas network) ➢ Relatively high (heat market)
Quality	➢ Low	➢ Low
Potential local market size	To be completed	To be completed

8. Market Status for Other Materials from MBT, AMT, or EfW-I

8.1 General comments

Commodity markets tend to be governed by the general economic cycle and when demand falls (nationally or internationally), prices fall and the lowest quality materials (whether from virgin or recycled sources) may find it difficult to find an outlet even at negative prices. Materials derived from MSW tend to fall into this category and many operators seek longer term contracts at relatively low prices (compared to spot market values) for their products to hedge against such market conditions. Currently demand for most materials which operate in a global market is high, fuelled by strong economic growth in Asia, particularly China and India. It is pertinent to note that since 2000, much of the growth volume in metals, paper and plastics collection has been exported overseas rather than leading to an increase in UK reprocessing capacity.

As with waste derived composts, materials recovered from residual wastes as opposed to source separation generally present a more difficult challenge in terms of securing market outlets. They tend to comprise a wider range of materials / products within the same generic material description (i.e. ferrous metal from source separation comprises canstock alone, ferrous metal from residual waste includes all magnetic metals – canstock, bottle caps, batteries, castings etc.). Also they tend to have higher levels of contaminants (mainly due to sorting inefficiencies) and often report higher levels of dirt, surface contamination, moisture levels than the equivalent source separated derived materials. However, unlike composts or SRF derived from residual waste, there is less prescriptive guidance as to suitability for end-use. They will still be considered waste by the regulatory authorities until recovered as a material of equivalent quality to virgin sources or incorporated into a product, but it is primarily the industrial users rather than the regulators that take the lead in proposing or imposing specification requirements or restrictive controls on use.

8.1.1 Metals

Having noted the above, there is little problem in finding markets for ferrous or non ferrous metals derived from RMSM. In some cases the treatment has beneficial effects such as removal of organics and sterilisation to offset the dis-benefits of a less homogenous product. Certainly ferrous metals should not attract a lower price than source-separated feedstock though, if subject to thermal processing, the product is much less likely to be of interest for de-tinning. For non–ferrous metals, the highest value component is aluminium canstock and most non-ferrous concentrates derived from RMSW will include foils and cast aluminium kitchen items. This will reduce the value, but the mix is still a very marketable product. Markets for metals can be considered to be international.

8.1.2 Papers

For a paper products derived from RMSW, the dominant mechanism will be handpicking prior to the bio-treatment stage of MBT. Corrugates (KLS) and other card along with news and magazines could all be targeted but KLS is probably the easiest to pick effectively, is likely to less contaminated and is most easily marketed for reuse in packaging. A news or magazine product is feasible for newsprint but the sector is prejudiced against use, particularly given the abundance of clean source separated feedstock. In the UK, the non mandatory standard BS EN 643, if applied would preclude use on quality grounds. A more realistic market from RMSW is a mix of newspaper grades with cardboard for marketing as a mixed paper grade for packaging use. This is a low value product, but simplifies sorting and recovery operations, is less restrictive in terms of the mix of paper grades and more tolerant of non-fibre contaminants. Whilst there is significant home capacity, markets for newsprint and packaging grade papers are international.

8.1.3 Plastics

For plastics, both MBT and AMT processes are capable of recovering a product. MBT plastics of similar form to source separated plastics, albeit with higher contamination levels. AMT plastics can be deformed by heat; container "dense" plastics retain basic size, film plastics tend to shred and shrink in the treatment stage. Only single polymer concentrates are likely to find a ready outlet and these must compete with cleaner source separated fractions. Mixed polymers and polymers with higher contrary levels can find outlets for low value "wood substitute" thick section extrusion moulding products. Finally mixed polymers can be used in feedstock recycling operations (converted to oligomers, syngas, or oils). There is limited current home demand but again international demand exists.

8.1.4 Glass

For glass, materials recovered from MBT/ATM are highly unlikely to be marketable for glass container use, but various lower value markets have been developed over the years, primarily in civil engineering applications as a substitute for sand or aggregate in non critical applications (e.g. pipe bedding, drainage media, glassphalt, and shot blasting). Although technically it is feasible to upgrade glass rich materials for recycling in glass furnaces, the technology is complex and expensive. Given the problems, it is considered more likely that glass would be recovered as part of a general "inert" product including rubble and ceramics as part of the mix for use in low grade civil applications. Developing local markets is usually considered vital for such materials.

8.2 Policy and regulatory issues

Although policy is generally very supportive of all recycling operations, as noted previously, materials recovered from incineration do not count towards LA recycling targets. Materials recovered from MBT and ATM do. The position regarding plastics directed towards feedstock recycling needs clarifying; from the perspective of the packaging directive, it would be classed as a recovery, not a recycling operation, but then this directive would count metals recovered post incineration as recycling, not recovery. Presumably the UK would be at liberty to reverse the position for plastics given the LA targets are a national, not international matter. As noted, there is an international market for commodities and status of materials recovered from MBT/ATM under transhipment regulations has yet to be established, in part because there is no accepted "specification" – the EA has ruled that mixed recyclables, even those derived from source separation, should be consider as "amber" rather than "green" waste and subject to the more stringent conditions agreed for this class of waste under the Basel convention. How would a plastics concentrate from an ATM plant be classified? These points illustrate that the issues noted for SRF and MLU on definitions and status also affect the more conventional products, albeit to a lesser degree.

To address such issues, WRAP have a number of projects dedicated to developing fitness for purpose specifications, an activity that is probably as important if less glamorous than the research and investment into developing new and existing markets for recyclates. Given the policy imperatives to promote a recycling economy, it can be anticipated in the medium term that such issues will be clarified and barriers to reuse lowered.

Mention has been made of the Packaging directive which places responsibility on the packaging chain to achieve minimum recycling levels for its products. Overall the major impact on providing support for household waste recycling to date has been improving the stability of markets for the recovered materials rather than direct investment in local authority collection infrastructure. Targets for 2008 will ensure that glass and metals recycling from household waste is a priority as the material targets are high and commercial and industrial sources of these packaging materials are very limited. For packaging paper and card, commercial sources will continue to provide the bulk of the industry commitment without major support for recycling of packaging paper and card from households. For plastics, the recycling target is relatively low (22.5% compared to more than 50% for the other materials) and the bulk of the commitment can be sourced from commercial and industrial flows (mainly shrink-wrap PE).

The packaging industry does recognise that bottle plastics from household sources will be an important source and consider that current levels could need to more than double to ~ 100,000 tpa by 2008 to ensure plastics meet their commitment. However this would still represent less than 25 % recovery for the plastic bottles available in household waste (and less than 7% of total plastic content). We can note from these brief overview comments that even within a given sector under producer responsibility, the dependency of that sector on household recycling activity is material specific and not predictable without deeper analysis. The most useful indicator of the problem facing the various sectors is the spot prices for material specific packaging recovery notes (PRN's); metals (both Fe and Al) and plastics are high this year at above £50/t; glass, paperboard and wood are all below £10/t. To date the increase in collection of packaging materials from household waste has not exceeded the packaging industries recycling commitments and they have had a significant incentive to ensure market outlets are available – either within their industry sector or by supporting alternative market options. LA's recycling activity could begin to exceed this industries needs later this decade (unless new targets are placed on this sector) and this may have an adverse effect for certain materials – most likely plastics and paperboard. Although there is a general recovery obligation which would encompass energy/fuel use of packaging papers and plastics, sufficient existing capacity (EfW-I) exists to meet industry's obligations.

8.3 Quality issues

Ferrous Metal (all systems); no significant quality issues in the foreseeable future

Non Ferrous metals (all systems); as produced, the mix does have lower value than source separated canstock, however it is marketable and should continue to be so for the foreseeable future

Paper and Card: (MBT); handpicking the most likely recovery technique. As produced, it is low grade and low value but could be graded better if required (probably at a reduced yield). It is marketable at present -primarily exported

Fibre (AMT); potential for wood substitute or fibreboard, but quality requirements have yet to be established

Plastics (MBT); single or mixed polymer is possible, primarily via handpicking. As produced, it is dirty compared to competitive source separated products but, technically, should meet existing market requirements.

Plastics (AMT); not proven in the marketplace as yet. Technically it should be possible to recover both single polymer and mixed polymer products via mix of mechanical / hydro-cyclone separation and/or handpicking. Bottle and other thick section plastic items of most interest and likely that industry requirements can be met. Given the shredding and/or shrinkage experienced for film plastics, meeting industry requirements other than as SRF or feedstock recycling is less likely. Effect of treatment on inherent polymer properties are not quantified, but it is unlikely to be a major barrier.

Inerts / Glass (MBT/AMT); it is technically feasible to produce low organic contaminated “inert” fraction for low grade civil engineering use. Specifications are not well developed for such applications and will be end-use specific. However, this is not likely to be a major barrier given the large potential market for non-critical civil engineering applications.

8.4 Technical Issues

For all the materials discussed, technically there are few problems that cannot be resolved given the investment in the necessary separation and refining systems. It is a question of cost and all stages in refinement will inevitably result in reduced yields. Each potential product need to be considered in the light of market requirements. In order of technical complexity and uncertainty with regard end market requirements, the plastics and inert fractions probably represent the more difficult challenges. A major issue relates to scale and complexity of the required upgrading/refining processes. At what stage in the chain should the investment be made; at the product producer, at the reprocessor or as a free standing merchant facility. Each material and project needs to be reviewed separately.

8.5 Commercial Issues

The main commercial issue beyond those already commented upon centre on the lack of experience of developing the systems and contractual relationships between producers and potential users for all RMSW products apart from the metals. In many cases – e.g. for AMT fibre, plastics and inerts, new markets and new end uses are proposed. There is a considerable task ahead to establish the required infrastructure and the lack of maturity in the market place will place the onus on the producer of such products to establish their own relationships with potential users. Only at this point will the full requirements for successful recycling become evident.

8.6 Other materials market risk - Summary

Table 13. Metals (all systems) – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Low	➢ Low
Technical	➢ Low	➢ Low
Commercial	➢ Low	➢ Low
Quality	➢ Low	➢ Low

Table 14. Paper (MBT) – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Low	➢ Low
Technical	➢ Low	➢ Medium
Commercial	➢ Low	➢ Medium
Quality	➢ Medium	➢ Medium / high

Table 15. Fibre (AMT) for material recycling – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Medium	➢ Unknown – high
Technical	➢ Medium / high	➢ Unknown – high
Commercial	➢ High	➢ Unknown - high
Quality	➢ Unknown - medium	➢ Unknown – medium

Table 16. Plastics (MBT) – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Low/medium	➢ Medium
Technical	➢ Low	➢ Low
Commercial	➢ Medium	➢ High
Quality	➢ Medium	➢ High

Table 17. Plastics (AMT) – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Low/Medium	➢ Medium
Technical	➢ Medium/High	➢ Unknown - medium
Commercial	➢ Unknown –high	➢ Unknown - high
Quality	➢ Unknown - high	➢ Unknown - medium

Table 18. Inerts / glass – Risk descriptors summary

Issue/criterion	Risk	
	Present	Future
Regulatory and policy	➢ Low	➢ Low
Technical	➢ Medium	➢ Medium
Commercial	➢ Medium	➢ Medium
Quality	➢ Unknown – medium	➢ Unknown - medium

9. Conclusions

Not withstanding any potential impacts of the factor local market size, general conclusions that can be drawn as result of the analysis presented in this report are outlined as follows:

i. Regardless of relative differences in the degree of regulatory and policy inhibition for SRF deployment in power plants, industrial boilers (incl. paper and pulp), and cement kilns, overall it seems that key changes would need to be made in this area to enable the establishment of viable SRF outlets.

ii. MLU is disfavoured by current conditions, particularly as far as higher quality outlets are concerned. Lower quality outlets may be viable provided that the local market size is adequate and markets currently exist with Leeds CC (e.g., parks, gardens) and/or the contractor(s) of the RMSW treatment facility(ies), or there is potential, in terms of size and penetration, for developing other local, low grade markets.

iii. Except for heat and LPG markets, that present some risk, biogas seems to be an output which should be able to find appropriate outlets in the power sector quite easily. Biogas electricity is financially supported through ROCs.

iv. For materials recycling, metals represent the lowest overall risk.

v. Providing the appropriate technology is in place, the situation for single polymer plastics and paper products from MBT is relatively stable although more difficult than the same products derived from source separation schemes. For ATM, the polymer products present more uncertainty regarding quality achievable and markets.

vi. Inert products / glass present similar quality uncertainty but the presence of large potential demand in non-critical low grade civil engineering applications reduces the overall risk. Additionally, disposal to landfill will not count as BMW disposal.

A general overview of the indication of market risks associated with each RMSW treatment option considered is presented in Appendix 2.

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Appendix 1

Treatment Options Considered by Leeds CC and Potential Products

Table A1.1. Treatment options considered by Leeds CC and potentially targeted products

RMSW Treatment Options	Potentially Targeted Products						
	MLU (incl. Fibre)	*SRF (incl. Fibre)*	*Metals (Fe/non Fe)*	*Inerts / Glass*	*Biogas / Syngas*	*Paper*	*Plastics*
Option 1 (AC+ATT)		•	•	•	•		•
Option 2 (AC)			•	•			•
Option 3 (EfW)			•	•			
Option 4 (MBT-C+ATT)	•	•	•	•	•		
Option 5 **(MBT-C)**	•		•	•			
Option 6 **(MBT-AD)**	•	•		•	•		

Keys to abbreviations; AC+ATT: autoclaving and advanced thermal treatment, AC: autoclaving, EfW: energy from waste incineration, MBT-C+ATT: mechanical and biological treatment featuring composting and advanced thermal treatment, and MBD-AD: mechanical and biological treatment featuring anaerobic digestion.

Appendix 2

Overview of General Marks Risks for Potential Products

Table A2.1. General overall market risk indication for the potential products of the RMSW treatment options examined

Option	Market Risk of Individual Products							General Overall Market Risk
	MLU (incl. Fibre)	*SRF (incl. Fibre)*	*Metals (Fe/Non Fe)*	*Inerts / Glass*	*Biogas / Syngas*	*Paper*	*Plastics*	
Option 1 (AC+ATT)	N/A	Low	Very Low	Moderate / Low	Very Low	N/A	High	**Low**
Option 2 (AC)	N/A	N/A	Very Low	Moderate / Low	N/A	N/A	High	**Moderate**
Option 3 (EfW)	N/A	N/A	Very Low	Moderate / Low	N/A	N/A		**Low**
Option 4 (MBT-C+ATT)	High / Moderate	Low	Very Low	Moderate / Low	Very Low	N/A		**Moderate / High**
Option 5 (MBT-C)	High / Moderate	N/A	Very Low	Moderate / Low	N/A	N/A		**High**
Option 6 (MBT-AD)	High / Moderate	Very High	N/A	Moderate/ Low	Very Low	N/A	N/A	**High / Moderate**

Keys to abbreviations; AC+ATT: autoclaving and advanced thermal treatment, AC: autoclaving, EfW: energy from waste incineration, MBT-C+ATT: mechanical and biological treatment featuring composting and advanced thermal treatment, and MBD-AD: mechanical and biological treatment featuring anaerobic digestion.