Material change for
a better environment

Local authority recycling

Recovering value from MRFs

A review of key studies relating to the specification, operation and costs of Materials Recovery Facilities

Materials recovery facilities (MRFs) are increasingly important in providing quality raw materials to industry.

Contents

Foreword

The UK is changing fundamentally the way it deals with its waste. From very low levels in 2000, recycling of waste has grown strongly and now stands at 27% for household waste in England and perhaps something over 50% for commercial and industrial waste. This change brings significant environmental benefits: in reducing the need to extract raw materials and in reducing climate changing carbon emissions by an estimated 10-15 million tonnes a year; equivalent to taking 3.5 million cars off the road.

The change has not been effortless. Local collection systems, sorting and reprocessing capacity as well as the end markets for materials have all had to adjust to these new demands with some parts of the system being more responsive than others. As the Government is reviewing its waste strategy for England and signalling that a further significant expansion in recycling will be needed, WRAP has been reviewing key parts of the recycling system to identify areas that will need further attention to maximizing the benefits from increased recycling levels.

Materials recovery facilities (MRFs) are increasingly important in providing quality raw materials to industry. MRF capacity in the UK is growing but it is unevenly distributed and investment in further capacity will be needed as demand grows.

In most cases, MRFs are designed to separate co-mingled recyclables[1] into their individual material streams and prepare them for sale into the commodity markets. Although few local authorities are likely to operate MRFs themselves, they will be involved in procuring services from private contractors that involve the design, commissioning and operation of MRFs. Understanding all stages from collection through sorting and bulking to the sale of recovered materials will ensure that, prior to embarking on the procurement route and preparing service specifications, local authorities are better informed about the cost implications of alternative options.

This summary document draws together the results of recent studies commissioned by WRAP and draws on good practice in MRF design and management from the USA and Europe. It is intended as an introduction for those unfamiliar with the issues surrounding the specification, operation and costs of MRFs.

1. Around one third of English local authorities collect recyclable materials co-mingled but this number is expected to increase as recycling programmes expand. Most of the remaining authorities operate kerbside sort schemes whereby materials are separated at the kerbside into their individual material streams. Collections are made using stillage or multi-compartment vehicles thereby avoiding the need for sorting of materials at MRFs.

Introduction

This summary document draws together the results of three separate studies commissioned by WRAP:

MRF Case Study Review (contractor: The Dougherty Group LLC), which looked at material sorting practices and technologies employed at a cross-section of MRFs in England, the USA and Europe;

MRF Cost Model and User Guide (contractor: Entec Consulting Ltd), which developed a costing tool for different materials sorting options; and

Contractual Arrangements between Local Authorities and MRF Operators (contractor: AEA Technology plc), which reviewed and assessed existing contractual relationships between MRF operators and local authorities across the UK.

It presents an overview of key aspects in the specification, operation and costs of MRFs with specific reference to:

- principles of MRF operations;
- the main steps involved in processing recyclables;
- costs and economy of scale benefits; and
- contractual arrangements to support investment and promote high standards of operation.

It is intended as an introduction for those unfamiliar with the issues surrounding the specification, operation and costs of MRFs. The full reports are available on WRAP's website – www.wrap.org.uk. The Cost Model is available on request.

MRF operations

There should be sufficient capacity to store at least two days' worth of incoming materials.

Receiving materials

It should be standard practice at a MRF for incoming recyclables to be received and stored, prior to processing, on a tipping floor which is protected from the weather. Water can significantly reduce the value of some recyclables especially paper and card. There should be sufficient capacity to store at least two days' worth of incoming materials. This will enable collection rounds to continue even during unscheduled equipment downtime and at times of high demand such as the post-Christmas period. It also gives the MRF a buffer so that it does not have to force material through the MRF faster than its design allows for, which can have adverse consequences for quality.

The tipping floor at a MRF. Incoming materials are received and stored here prior to processing.

Pre-sorting

Inclusion of an adequate pre-sort station in a MRF can deliver quality control and efficiency benefits. Pre-sorting not only allows removal of contaminants early in the sorting process, but also permits removal of specific recyclables that might otherwise hinder sorting activities downstream. Materials such as film plastic, oversized cardboard as well as non-recyclables (organics, wire, wood etc) can cause problems for some of the automated processing equipment, and can be removed at the pre-sort stage. This enables the processing equipment to operate as designed and makes manual sorting more efficient. Although pre-sort stations are common in North American and European MRFs, they are not incorporated in all MRFs in the UK.

Managing flows

Efficient sorting critically depends on a continuous and even flow of material being maintained through the MRF. Levelling out the flow of material occurs as the materials enter the sorting process. This can be achieved by using a series of conveyors operating at variable speeds, stationary gates or metering drums.

Processing recyclables

Manual sorting at a MRF.

Separating fibre from containers

In a MRF accepting fully co-mingled materials, one of the first processing steps involves separating fibre streams (i.e. paper, card, cardboard) from container streams (i.e. cans, plastic bottles, glass bottles/jars). A trommel screen typically is used for this purpose in the UK. In North America disc screens are more common. Depending on the size of the MRF, several stages of screening may be involved. The overall aim is to enable separate fibre and container streams to undergo appropriate sorting.

Sorting fibre

To meet market specifications, fibre needs to be sorted into its various grades. Typically, MRFs in the UK sort three grades of paper: OCC (old corrugated cardboard), news & pams (periodicals and magazines), and mixed paper. Some MRFs only sort into OCC and mixed paper whilst some MRFs in North America sort into six grades.

Sorting can be done (i) manually, (ii) using disc screens or (iii) using more advanced optical scanners. Smaller MRFs tend to rely on manual sorting, while larger facilities use disc-screens. The use of optical scanners is relatively new and, due to high capital cost, generally confined to high-throughput MRFs.

MRFs that 'negatively sort' paper (i.e. allow it to run off the end of the conveyor belt after other materials should have been extracted) have experienced quality-related problems when the materials have been shipped to UK paper mills. In some cases, loads that do not meet UK mill specifications are shipped overseas for recycling.

The quality standards set in the UK do not have the clarity of the specifications used in some other countries. MRFs in the UK frequently appear to be guided by rather broad specifications (e.g. <1% contamination) which vary for individual reprocessors and which appear to have fairly ad hoc enforcement arrangements.

Sorting can be done manually, using disc screens or using more advanced optical scanners.

The system for developing acceptable standards for supplying paper to UK paper mills appears to be based on bilateral arrangements between individual MRFs and individual mills.

The following steps are therefore recommended:

- where this is not already done, paper specifications should be (i) well publicised and (ii) available on paper mills' and reprocessors websites so that all potential suppliers have access to them;
- implement testing procedures to determine quality of materials received at mills. Whilst this is undertaken at several UK mills, there is no standard testing procedure. The adoption of similar procedures across the sector could improve the quality of materials received and potentially allow the development of a price differential in favour of good quality materials; and
- a continuous feedback system, advising MRFs of the quality of materials received during any given month, should be implemented. Results of random tests can be emailed to the MRF, enabling a quick response by the MRF manager in cases where the quality of a shipment is not consistent with that of previous shipments.

paper specifications should be well publicised

Sorting glass containers

Only a limited number of UK MRFs that process co-mingled dry recyclables accept (container) glass as part of the incoming stream. Where glass is collected at kerbside, this is mostly carried out using kerbside sort systems which keep the glass separate from the paper and other materials. However, several of the newer MRFs in the UK are accepting glass and it is possible that collection cost pressures will encourage more local authorities to consider including glass in co-mingled collections.

Most co-mingled MRFs in North America process glass, believing that it can be effectively separated from paper using multiple disc screens. The paper is shipped to pulp mills and glass is sent to glass container manufacturers. This approach is not accepted by UK paper mills who are concerned that the quality of paper coming out of MRFs is not meeting their needs. Glass contamination of the paper stream, in particular, is considered to be a significant business risk. As a result the majority of paper sorted at MRFs where glass is part of the incoming materials is exported.

Where glass is handled in MRFs it is relatively easy to separate from other containers (e.g. plastic bottles and cans) because of the density differences of the materials; an air classifier can be used to separate most of the glass from the plastics and cans.

Although there are significant price differentials for clear, amber and mixed glass, reflecting the different supply and demand for each of these materials, colour sorting of glass does not take place in any UK MRF. The majority of the glass recovered goes to aggregates markets. Colour sorting capacity, however, is being installed by the major container glass reprocessors. The decision on whether colour sorting of glass is viable from an economic viewpoint is being made on a case by case basis by the MRF operator.

Sorting metal containers

Technologies capable of separating steel (i.e. ferrous) and aluminium (i.e. non-ferrous) cans from other containers are reliable and common. Overband magnets and magnetic head pulleys in conveyors will readily separate ferrous cans, while eddy current separators are typically used to sort aluminium cans. In view of the high value of (and stringent specifications for) aluminium, manual quality control should be employed following sorting and before baling to ensure the product meets market requirements.

Sorting plastic containers

A significant challenge for UK MRFs will be increasing their capacity to sort plastics into a wider range of polymers. Currently, many local authorities in the UK restrict plastic collections to bottles only. The limited capacity currently available to sort mixed plastics is a constraint on recycling much domestic plastic waste especially packaging. It is also a factor in the UK's current reliance on export markets for mixed household plastics.

In a MRF, plastics are sorted by resin (typically HDPE and PET) using both manual and automated techniques. Manual sorting by resin is most prevalent, however efficient automated sorting is carried out primarily through use of optical scanners. Optical systems can be used to sort multiple grades of plastic, but are more costly to install and need high volumes to justify their costs.

Bailed aluminium cans.

Baling and shipping

Decisions on whether or not to bale materials processed at a MRF must take into account market requirements, market prices and the difference in the cost of transporting materials baled or loose. Although most materials processed at a MRF are baled before shipment to market, many MRFs in this country deliver paper loose (i.e. not baled) to UK markets/ paper mills.

A baler tends to be the single most important piece of equipment in a MRF. When selecting a baler, the key is to ensure that it will provide sufficient baling capacity, as well as produce bales that meet market requirements in terms of size, density and weight. If there is only one baler and it becomes disabled, the entire sorting process can be compromised. It is therefore advisable to consider investing in back-up arrangements which might be access to another baler or appropriate on site storage facilities.

As an alternative to baling, materials (particularly cans) can be crushed and loaded loose for transportation to a merchant or processing facility.

Just as incoming materials need a covered tipping floor which is large enough to cope with breakdowns and delays, so there needs to be adequate storage for sorted materials including covered storage for materials which can deteriorate in quality, for example, paper.

Managing residues

Residues from a MRF consist of (i) non-recyclables (i.e. contaminants) that are mixed in with the targeted recyclables delivered to the MRF and (ii) recyclables that are not sorted during processing. Residues are expensive to collect, process and dispose of, so MRF operators should strive to minimise them. This can be achieved by:

- auditing incoming recyclables to identify levels and types of contamination and providing regular feedback so that local authorities can take action;
- working directly with collection authorities to reduce contamination levels in incoming materials;
- applying differential gate fees to reward local authorities whose collections contain low levels of contamination;
- conducting residue audits to identify quantities of missed recyclables, and then working to improve processing efficiencies; and
- putting residues into the sorting system for a second time to ensure that all recyclable materials are taken out.

Costs

MRF Cost Model

As a result of work to establish the typical costs involved in setting up and operating a MRF, a costing tool has been developed and is available, on request, from WRAP. The MRF Cost Model provides representative capital and operating costs for a range of MRF sizes. Specifically, it gives the user the chance to tailor several specified MRF designs to local conditions and to determine sorting costs resulting from:

- specific MRF design parameters (e.g. capacity of the tipping floor and product storage areas);
- operating conditions (hours, shifts, days per week etc);
- decisions on whether incoming recyclables are to be fully co-mingled or two stream;
- whether they are to be bagged or loose, and whether or not glass is to be included;
- designation of which materials are to be manually sorted;
- designation of which materials are to be baled;
- labour rates for operating and supervisory staff;
- designation of recovery rates for targeted recyclables;
- shipping costs for materials to be marketed and revenue from the sale of materials; and
- baling wire costs, disposal fees for residue disposal, charges for electricity consumption, the unit cost of constructing the MRF building etc.

By changing these variables, the user can assess the impact on overall costs. The user is therefore able to identify, for a MRF of a particular capacity:

- the cost of a two-stream[2] and a fully co-mingled sorting system;
- the cost of adding glass to the incoming recyclables stream; and
- the additional costs associated with processing bagged recyclables at a fully co-mingled MRF.

These alternatives can be investigated not only for a wide range of operating parameters but also in the context of a range of options for marketing the sorted materials.

If used in conjunction with the Kerbside Analysis Tool (KAT – also available from WRAP), the MRF Cost Model will enable local authorities to understand the total costs of managing the collection, bulking and sorting of dry recyclables and to compare the relative costs of different systems.

Materials included within the MRF Cost Model as targeted materials (i.e. those designated by local authorities as officially part of their collection schemes and which householders are asked to recycle) include:

- Fibre: news and pams, magazines, directories and catalogues, recyclable paper, paper and card packaging, cardboard; and
- Containers: ferrous food and beverage containers, ferrous aerosol cans, aluminium food and beverage containers, aluminium aerosol cans, glass bottles/jars (clear, green and brown), all plastic bottles.

Most of the incoming recyclables are assumed to originate from a local authority recycling programme, including materials collected through kerbside, estate and bring sites. The recovery rates reflect a 'good practice' standard that local authorities are likely to aspire to over the next five years as recycling programmes expand.

The MRF Cost Model provides representative capital and operating costs for a range of MRF sizes.

Additional processing costs per tonne at full capacity can range from £6 - £10.

2. Some MRFs are designed to accept incoming materials in two streams. In some cases fibre is kept separate from containers (glass, plastics, cans) at the point of collection; in other schemes glass is kept separate from the other materials.

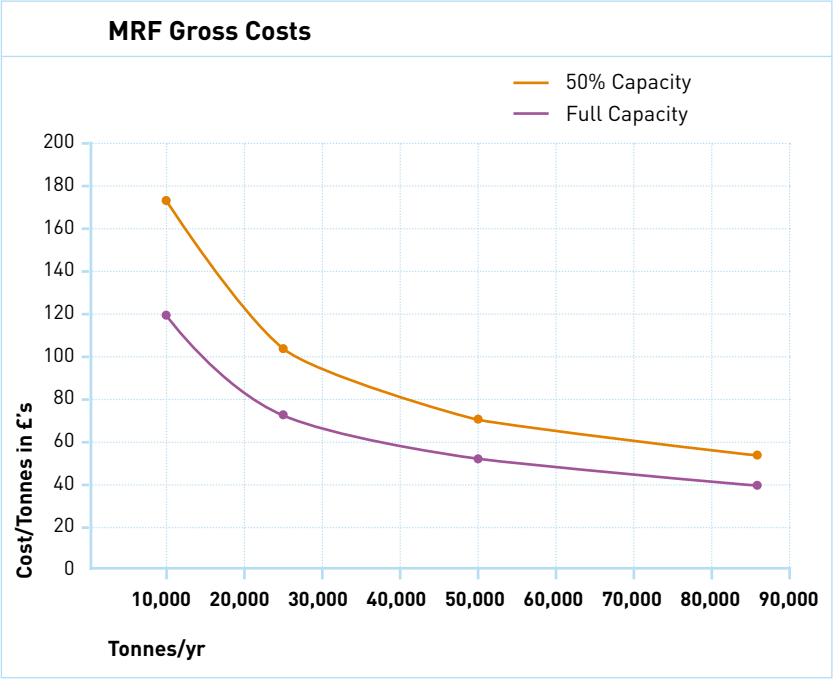
Cost implications

A sample cost curve for MRF operations has been derived from the MRF Cost Model and is presented below. This shows the variation in the unit cost per tonne for MRFs of different design capacities. It shows that the unit cost per tonne begins to level out at higher throughput tonnages (80,000 – 100,000 tpa) but rises significantly at lower throughput tonnages. In the example given the cost of an 80,000 tonnes per year facility operating at full capacity is £40 per tonne, compared to £80 per tonne for a 40,000 tonnes per annum facility.

The cost curve also shows the cost implications of operating a MRF at 50% capacity (i.e. on a single-shift) compared to full capacity (i.e. a two-shift basis). The lower of the two cost curves applies when a MRF is operating at full design capacity. Any reduction in throughput tonnage below that level increases the unit cost of processing. For a facility with a design capacity of 80,000 tonnes per year, the cost differential between operating at full capacity and 50% capacity is almost £20 per tonne. MRFs operating at above design capacity risk failing to meet quality standards.

MRFs operating at above design capacity risk failing to meet quality standards.

Fully co-mingled MRF – cost per tonne.



As a result of the work underpinning the development of the model some broad conclusions can be drawn regarding the sizing of MRFs and the opportunities to achieve economies of scale.

- **Processing higher tonnages can be economically advantageous**
  The MRF cost model suggests that MRFs below an annual capacity of 80-100,000 tonnes will not achieve optimal operating costs. Facilities of this scale are needed to achieve economies of scale but also to justify investment in more automated and sophisticated sorting equipment that will help maximise the value of the recovered materials. By sorting incoming materials into more categories, the value of these materials can be increased. Historically UK MRFs have tended to be smaller (less than 50,000 tonnes per annum) although new capacity is being planned at this size or significantly greater.
- **Processing costs at a fully co-mingled MRF are higher than those at a two- stream MRF of the same size**
  At a fully co-mingled MRF, more sorting is required to separate out different recyclable materials. For the example facilities included in the cost model, the additional gross processing costs range from £6 per tonne (at an annual throughput of 85,000 tonnes) to £23 per tonne (at an annual throughput of 10,000 tonnes).

Contractual arrangements

To maintain competition and cost transparency, local authorities may decide to tender sorting and collection functions separately, where this is appropriate.

Contractual relationships between MRF operators and local authorities

There are a number of possible frameworks within which MRFs can operate. They include the following, the first of which is by far the most prevalent in the UK:

- a MRF operator sorts materials from local authority collection schemes and charges the local authorities a gate fee;
- a private contractor collects the materials (under contract to the local authority) and that same company operates the MRF and charges the local authority(s) for collection and sorting;
- a local authority owns and operates its own MRF;
- a local authority owns and operates its own MRF and accepts materials from other local authority schemes (typically charging a gate fee);
- a local authority owns the MRF and contracts the operation to a private contractor; and
- a consortium of local authorities own the MRF and contract the operation to a private contractor.

In some cases in the UK, formal contractual agreements are not in place between local authorities and the MRFs they use.

Irrespective of the precise nature of the agreements, all parties involved in operating a recycling system must work together closely, with each carrying out its responsibilities efficiently in order for the others – and the system as a whole – to succeed.

Safeguarding and improving performance

Contractual arrangements can be framed in ways that incentivise good performance and can incorporate mechanisms for monitoring contract performance. In the UK some contractual arrangements do not include incentives or performance criteria to increase recovery rates and achieve required quality standards; performance standards were found to be more common in Europe and North America.

The advantage of incentives and monitoring mechanisms is that they enable the relevant parties to be clear about the extent to which they are carrying out their responsibilities efficiently and also highlight specific areas where efforts to improve performance may be targeted.

When drawing up and managing contracts, options and issues to consider include the following:

Performance-based contracts

Local authorities can stipulate performance levels to be achieved by the company contracted to carry out the sorting process. Performance indicators can include vehicle turn-round times, availability requirements, material quality, material rejection rates, residue rate, market prices achieved, overall recovery rate, etc.

Identification of materials to be sorted

To ensure the success of kerbside recycling programmes, local authorities should determine the materials to be included in collections. Individual companies can then be invited to submit bids for sorting the materials collected, outlining costs that will be incurred and revenues that will be generated. To maintain competition and cost transparency, local authorities may decide to tender sorting and collection functions separately, where this is appropriate.

Processing efficiency and permissible residues

Contracts with MRFs should specify an acceptable maximum level of process residue. Efficient MRFs appear to operate within the range 2% to 5% residue. Processing efficiency targets can therefore be based on the percentage of input material processed, with financial deductions and bonuses for performance below or above the agreed efficiency rate; alternatively, an excess charge (e.g. £90 per tonne as in one example identified) could be made for materials rejected during the processing phase.

Establishing sorting costs and revenues

Tenders and contracts for the sorting of kerbside materials should stipulate the cost per tonne of sorting the specified materials, the minimum revenue to be generated from the sale of sorted materials, and a plan for returning part of the revenue to the local authority, to help offset the direct costs of collecting the materials. Achieving top price for sorted materials is therefore an important requirement.

Typically, it is the responsibility of the MRF operator to secure markets for recovered materials. As well as stating anticipated prices for sorted materials, the contract should have a mechanism for varying prices from time to time in line with market fluctuations.

Where local authorities retain income from the sale of materials, this income may be reinvested in the service to reduce the gate fee paid or offset the costs of collection, giving the local authority an incentive to maximise the quality of the recyclables it collects. However, a reduction in gate fee may mean that the MRF operator would not benefit from the additional income generated and might not be incentivised to obtain the best price for recovered materials.

Where these are in place, revenue-sharing arrangements between local authorities and MRF operators typically involve a 50/50 split. Clearly, where revenue is shared between all parties involved in the operation, there is an incentive to maximise quality in both the collection and the processing of recyclable materials.

Visual inspection and random sampling

MRF operators generally visually inspect incoming loads for contamination. Where the specified contamination limits are exceeded, loads may be rejected with the cost incurred by the local authority, thus providing an incentive for that authority to manage the quality of the materials collected.

Random sampling from collection trucks to check for contamination should be conducted by the MRF on a monthly basis, with the resulting audit reports forwarded to the local authority and/or the collection contractor within a day or two.

Moving sorted items for transport.

Conclusions

These studies have raised a number of issues related to the specification, operation and costs of MRFs. In particular they emphasise the importance of MRFs producing consistently high quality materials. The implications of MRFs not achieving this is that materials are offered to the market that do not meet the quality specifications required by UK reprocessors and possibly, as a result, lead to more materials being exported.

WRAP believes there is a role for more MRF capacity in the UK, but this capacity needs to be of the right sort, be in the right place and be capable of delivering quality materials that meet end market requirements.

In terms of the 'right location' a balance needs to be struck between achieving the economies of scale offered by larger facilities and the potentially higher transportation costs associated with delivering materials to larger, more centralised MRFs. Many of the larger metropolitan areas will produce the required volumes of material allowing larger facilities to be situated close to the collection areas. For semi-urban and rural areas, the costs of running a number of smaller, local facilities need to be compared with the higher transportation costs but potentially lower unit costs of sorting at larger facilities. When considering the latter option, it is essential to ensure that it represents a satisfactory solution in terms of balancing costs, efficiency and environmental impact. The MRF cost model and other costing tools provided by WRAP can help inform such decisions.

WRAP is undertaking further work to better understand the characteristics of current MRF capacity and where additional capacity is most likely to be required in the future.

One challenge to be addressed, especially in two tier local government areas, is for decisions on recycling services to be made in the light of the full cost of the service i.e. collection and sorting costs and not on sorting or collection costs alone.

In terms of the 'right sort of capacity' WRAP believes that MRFs should develop as "value factories", ensuring that maximum value is obtained from the recovered materials both through sorting and preparing these materials ready for use by reprocessors.

This will require facilities that:

- are appropriately sized;
- adopt appropriate sorting technology;
- are integrated with collection systems and able to handle materials from a number of collection schemes. MRFs can be designed to process fully co-mingled household recyclables alongside more segregated streams by using separate in-feed lines;
- have good quality control and feedback systems;
- have committed management and trained staff; and
- effective regulation.

It will also require:

- contractual or other arrangements that incentivise those that send materials to MRFs, to take an interest in the standards that are achieved;
- contractual or other arrangements that incentivise MRF operators to lower unit costs of sorting and increase the revenue from the sale of the processed materials; and
- clearer quality standards for recovered materials, particularly paper, and the adoption of standard testing procedures to determine quality of materials received at mills from MRFs.

WRAP works in partnership to encourage and enable businesses and consumers to be more efficient in their use of materials and recycle more things more often. This helps to minimise landfill, reduce carbon emissions and improve our environment.

Waste & Resources Action Programme

The Old Academy
21 Horse Fair
Banbury, Oxon
OX16 0AH

Tel: 01295 819 900
Fax: 01295 819 911
Email: info@wrap.org.uk

Helpline freephone:
0808 100 2040

www.wrap.org/materials

recycle