Report

A Business Case for Mattress Recycling in Scotland

A Business Case for investment in infrastructure

Zero Waste Scotland works with businesses, individuals, communities and local authorities to help them reduce waste, recycle more and use resources sustainably.

Find out more at www.zerowastescotland.org.uk

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Glossary

EfW	energy from waste
ft^2	square feet
HSE	Health and Safety Executive
HWRC	household waste recycling centre
LA	local authority
p.a.	per annum
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations
SEPA	Scottish Environment Protection Agency
ZWS	Zero Waste Scotland

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Background
This document sets out to assess the viability of mattress recycling in Scotland and explore a business case for potential development of this activity. It is estimated that, at present, 15% of mattresses in the UK are recycled at end of life: however, only a low level of mattress recycling capacity is active within Scotland at the time of writing. This lack of capacity indicates that there may be potential for developing recycling operations within Scotland.

The environmental case and policy drivers for mattress recycling are clear. Mattresses are a problem for waste management; they most commonly arise from the domestic market and are collected by local authority services to be sent to landfill. It is estimated that 8,000 tonnes of mattresses are disposed of by local authorities in Scotland, with the majority ending up in landfill (£80 per tonne) at a cost to them of around £640,000 p.a.

There are several policy and environmental drivers which support the need for alternative processing routes. This is particularly true of recycling, as mattresses contain many materials including steel, textiles and polyurethane foam which, if separated, have a value to recycling end markets. Capturing these materials for recycling or recovery aligns with the Scottish Government's Zero Waste Plan, which sets out objectives for resource management to 2025 (targeting a 70% recycling rate and 5% of waste sent to landfill) and emphasises the need to capture materials to minimise demand for virgin raw materials for Scottish manufacturing. Developing the infrastructure for mattress recycling will contribute to these targets, offering a potential business opportunity and providing a source of materials to end markets.

Operational plan
Based on the evidence gathered, a localised mattress recycling operation in the Glasgow area using manual separation is proposed as the most feasible option for mattress recycling in Scotland, though the case is economically marginal without external interventions. The high quantities of waste mattresses produced in this comparatively small geographical region and the lack of competition means it is most favourable to locate here. Local authorities provide the most suitable source of mattresses, with the ability to supply a constant stream. Mattresses collected from other sources, such as retailer take-back schemes, can be used to augment the supply from local authorities. Once delivered, mattresses would be manually deconstructed by operatives, and the separated materials sold on to end markets for recycling. However, some development of these markets may be required. This operation offers the most economic option for this scale at present, and avoids the use of machinery which can sometimes be problematic.

Within the outlined three year plan, the operation will start with two operatives deconstructing mattresses by hand. This will expand to four and finally eight in Year 3. The planned operation would have a capacity of 10,000 mattresses in Year 1, rising to 18,500 in Year 2, and reaching 34,200 in Year 3. This final figure represents around half the mattresses collected by local authorities in Glasgow City, North Lanarkshire and Renfrewshire. Other locations could be expanded into, such as regions around Edinburgh and Aberdeen, which also have high levels of mattress arisings.

Financials
Start-up costs are minimised by this operational plan as there is minimal need for equipment; a forklift truck and a textile baler are the only large pieces of equipment required. Including other up-front costs, total start-up investment is estimated at around £15,000. The largest on-going costs are associated with salaries and property costs which, over the three years, respectively account for 65% and 31% of operating expenditure.

Income is based on a starting gate fee of £6.25 per mattress plus sales of materials sent for recycling. This gate fee was set using information gathered from other recycling operations in the UK and evaluation of the business financials. This is higher than usual within the industry (£4 to £5 is more common), but is required to sustain the business. The value of materials to end markets is estimated at £1.15 per mattress, based on average mattress composition. In this scenario, steel and textiles are sold on for recycling and other materials are processed to energy from waste or equivalent. Based on the developed model and assumptions, a three-year financial forecast indicates that the business breaks even in Year 2 and makes a profit in Year 3. Cumulative net cash flow will still be negative after three years, but is likely to be positive in Year 4 if performance continues as before.

Barriers
Several barriers to the development of mattress recycling infrastructure in Scotland were identified. Of these, the most important are linked to economic factors, and in particular:

- obtaining a high enough gate fee to sustain the business and therefore make it attractive for development;
- high reliance on the gate fee for sustaining the recycling business due to the low value of materials to end markets (this is linked to the poor quality of materials arising from mattresses and inadequate collection methods lowering the value further); and
- inability to reduce costs further due to tight margins.

These issues linked together mean there is little incentive for development from an economic perspective. Other barriers arise around operations; particularly in ensuring that a supply of suitable mattresses that are clean and dry can be found. Buy-in for the service from local authorities is also critical, as the business is reliant on this for operation. Landfill is cheaper than recycling at present, and evidence suggest that it will continue for at least 3 years, despite the increase in landfill tax over this period. Therefore other drivers such as the need for environmental performance or landfill avoidance are required if local authorities are to engage in mattress recycling. This is also true for retailer take-back schemes which are exposed to similar economic pressures.

Interventions
External interventions are likely to be necessary to make mattress recycling attractive to investors and to initiate the development of commercial mattress recycling in Scotland. For example, the Scottish Government could provide incentives for businesses and support to on-going operations through direct actions. Most crucially these should provide greater certainty over the income from each mattress processed, removing some of the risk associated with the income stream. Options include:

- Subsidies and grants for recyclers, potentially based on the number of mattresses processed or on materials sold on to end markets.
- Grants or loans could be provided to purchase capital equipment at start-up, or later on in the business cycle to improve efficiency or capacity. This would remove the need for up-front finance and lower any debt burden arising before cash in-flow from gate fees and materials has started.
- Interventions could also aim to support the business by reducing on-going costs; for example, through subsidies for business rates or leasing. These are the largest costs associated with the business, so intervention would provide steady support for the business.
- Supporting innovation in technologies and techniques which enable lower cost mattress recycling.

Actions such as these could be funded through the introduction of an advanced disposal fee, which would feedback money into such schemes. This fee would be included in the sale of a mattress, increasing its price by a small amount but leading to the reduction of waste sent to landfill. A similar approach has been successfully adopted for tyres. Other interventions could be indirect or occur through policy changes:

- Development of end markets for materials, for instance for reprocessing into new mattresses, to provide additional and higher quality options for materials.
- Stipulation of a gate fee for waste mattresses by the Scottish Government to help support recyclers.
- Development of existing retailer take-back services which more closely fit with recycling operations and have wider coverage. Potentially this could be facilitated through an extended producer responsibility approach.
- A better understanding of collection economics and reverse logistics for mattresses could be developed to identify whether interventions could be made during this stage.
- Improvements in design to enable simpler deconstruction and separation into higher value materials.
- Banning mattresses from landfill to ensure that alternative disposal options such as recycling are developed.

Competition and risks
The key risks to this business are obtaining agreement from local authorities to ensure delivery of dry unsoiled mattresses and, most critically, agreeing a gate fee which is able to support the business costs. The gate fee required to sustain this business is higher than is found elsewhere in the UK.

The main competition to this business was identified as existing waste processors, who may either send mattresses to landfill or shred them as part of general waste processing. Shredding can present a lower-cost option to landfill and leads to the recovery of some metals. However, this shredding process lowers the quality of the materials obtained from mattresses, limiting their use and value. In additions Oran ES have recently begun recycling operations in Clackmannanshire, however the scale of this operation is unclear at the time of writing.

1 Context

The need to investigate alternative methods of disposal for mattresses stems from the Scottish Government's Zero Waste Plan launched in 2010.[1] The Plan sets out how waste will be viewed and managed over a 15 year timescale, and how to maximise the use of available resources through the wider implementation of re-use, recycling and recovery of materials,[2] Within this overarching strategy two important targets for 2025 have been set for waste treatment: a 70% recycling rate, and a maximum of 5% of waste sent to landfill. The need for this rapid action is highlighted by recent figures for landfilled waste; in 2010 non-hazardous waste sent to landfill totalled 4.04 million tonnes in Scotland.[3] The total remaining Scottish capacity is 64.0 million tonnes, or 15 years' capacity at the present rate of disposal.

Mattress sales are dominated by the domestic market, which accounts for an estimated 81% share. Consequently the majority of end-of-life mattresses are processed through local authority (LA) waste management schemes after disposal by households. Within Scotland it has been estimated that waste mattresses collected through LAs account for close to 8,000 tonnes of waste sent to landfill.[4] The actual total figure for mattresses is likely to be larger due to other disposal routes, such as retailer take-back, which lead to further landfill waste. Although this is a low proportion of waste sent to landfill in weight terms, the bulky nature of mattresses mean that they account for a large volume of landfill waste. One tonne of uncompressed mattresses has a volume of around $23m^3$, corresponding to about $184,000m^3$ for mattress disposal through LAs each year. There is also a cost to LAs associated with this practice, which can be estimated to be around £640,000 p.a. based on current costs for landfill disposal.[5] In addition, sending mattresses to landfill prevents the recycling of materials - a key target of the Zero Waste Plan.

Despite these policy and environmental drivers, mattress recycling in the UK and Scotland only occurs on a small scale. It is estimated that in 2011 15% of waste mattresses were recycled.[6] However, this is believed to be an over-estimate - particularly when applied to Scotland - due to inaccurate reporting of recycling figures across the UK and a specific lack of activity in Scotland. Therefore an opportunity exists to reduce waste sent to landfill and increase the rate at which materials can be recycled through development of Scottish mattress recycling infrastructure.

Using evidence from existing mattress recycling organisations, the waste management sector and material end markets, a business case has been developed for mattress recycling in Scotland. The data used in the business case is detailed in Appendix II and Appendix III; Appendix I provides additional supporting information for the business case. This business case is reliant on several assumptions which are outlined within the document. The work has set out the parameters of a high level business model for mattress recycling in Scotland and sought to identify conditions in which it may be viable. The conditions for viability are achievable but stretching. This provides a concrete framework for dialogue with industry and stakeholders. Further business-specific analysis would be required prior to take-up, for instance precise location of materials end markets.

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[1] Scotland's Zero Waste Plan, The Scottish Government, Edinburgh 2010
[2] http://www.scotland.gov.uk/Topics/Environment/waste-and-pollution/Waste-1
[3] http://www.sepa.org.uk/waste/waste_data/waste_site_information/landfill_sites__capacity.aspx
[4] Appendix II - Arisings and disposal routes of mattresses in Scotland and the UK
[5] Based on 2012 landfill tax of £64 per tonne (due to rise at £8 per year until 2014), plus an average gate fee of £18 per tonne for landfill in Scotland.
[6] Appendix III – Scottish Mattress Recycling Capacity

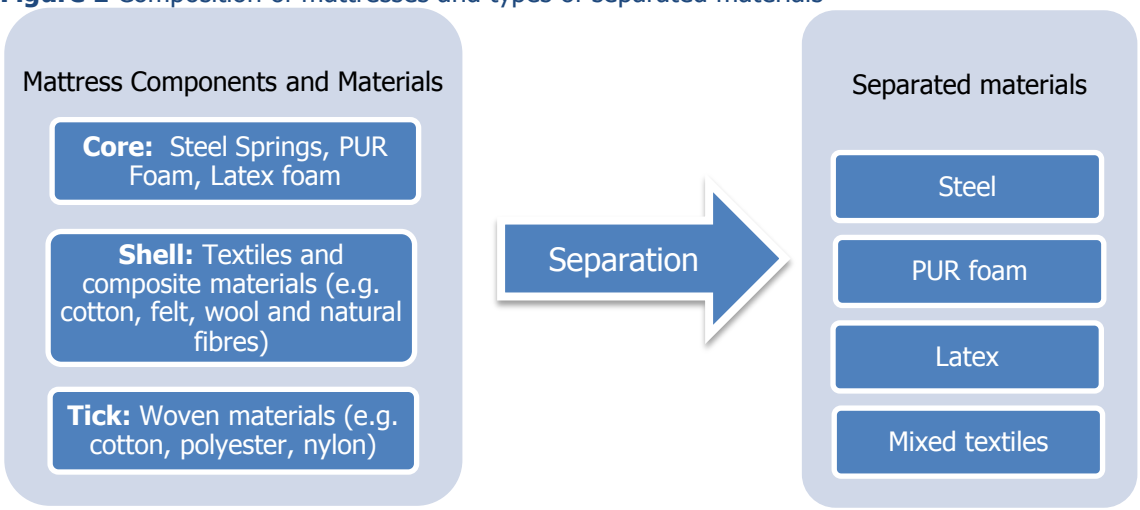
2 Introduction to mattress recycling

Before examining the detailed case it is useful to provide some indication of the scale of mattress waste, describe the current situation within Scotland, and outline what mattress recycling entails as a process.

The largest source of end-of-life mattresses is via local authorities from through the domestic market. Estimates indicate that 370,000 waste mattresses are collected by bulky uplift and through household waste recycling centres (HWRCs) in Scotland annually, corresponding to around 7,800 tonnes of mattresses.[7] Based on an average UK recycling rate for mattresses of 15%, the total weight of mattresses sent to landfill in Scotland each year can be estimated at 6,600 tonnes through household waste recycling centres (HWRCs), which represent by far the largest source of end-of-life mattresses. To date, only one project is known to have successfully recycled mattresses in Scotland: SpringBack, a social enterprise project run by FEAT based in Fife. In 2007, SpringBack was one of the first organisations in the UK to undertake this activity. However, as of 2011 many of the assets and contracts were sold off and, as a result, the overall recycling capacity in Scotland appears to have reduced significantly from previously stated figures, and it is unclear whether recycling is occurring at present but it is likely to be in low quantities. Therefore, there is a potential opportunity for the recycling of mattresses in Scotland if a viable business case can be developed. This is a particularly opportune moment due to the emerging policy drivers discussed previously.

The actual process of mattress recycling generally involves processing waste mattresses into constituent materials and supplying these materials on to relevant end markets. The composition of mattresses varies greatly, but they are usually categorised based on their main core material, which fall into three common types; steel springs, polyurethane foam, and latex foam. Mattresses may also contain other shell materials surrounding the core, and tick which contain and protect the internal sections of the mattress, see Figure 1. Different material types are separated to achieve maximum value in end markets, therefore motivating the need to disassemble and isolate materials types.[8]

Figure 1 Composition of mattresses and types of separated materials



This separation of materials forms the core activity for mattress recycling, as sales of materials such as steel from springs and textiles from filling materials is a key source of income. In general, this process is carried out by hand because the variability in construction, design and materials, makes the process difficult to automate effectively

[7] Estimation based on figures from Appendix II
[8] Estimation based on figures from Appendix II

The following sections describe a business case for developing a mattress recycling operation in Scotland. The approach taken has been to review existing mattress recycling processes and utilise data gathered on Scottish waste arisings to model the viability of similar business models in Scotland. Based on this information, a three year plan is described demonstrating how a business might grow. The plan also assesses income, costs and other factors that are critical to a potential mattress recycling business.

3 Market research

3.1 Supply and sourcing of end-of-life mattresses

Annual consumption of mattresses

Based on ONS figures, the number of mattresses sold in Scotland in 2010 is estimated at 541,000, this compares with an estimated 370,000 collected through LAs.[9] These fall into three categories based on the mattress core; latex foam, polyurethane (PUR) and springs. Table 1 provides a breakdown of each mattress type, with number of units sold, total weight, and average weight presented. UK production data indicates that the majority of these mattresses were manufactured in the UK, most likely due to costs associated with transporting these items long distances.

Table 1 Total estimated Scottish mattress consumption (domestic and commercial), 2010

Mattress type	Total (Units)	Unit %	Weight (tonnes)	Weight %	Average weight (kg)
Spring	371,800	69%	9,300	80%	24.4
PUR foam	160,700	30%	2,100	18%	13.1
Latex	8,200	2%	190	2%	22.7
TOTALS	**541,000**		**11,590**		**21.4**

Source: calculated from ONS PRODCOM, 2010 estimates; using industry conversion factors detail provide in Appendix II

Though this is consumption data, it provides some insight into the types of mattress being disposed of. These proportions have remained fairly constant over the last decade and are representative of the composition of mattresses available for recycling today. These figures also give an indication of the total scale of mattress arisings in Scotland. Around 81% of these mattresses are sold to the domestic market, and therefore disposed of by households. Other markets include care homes (9%), hospitality (8%), and hospitals, prisons and armed forces (2%).[10]

Local authority arisings

The majority of mattresses are disposed of through LAs, and it is estimated that around 370,000 mattresses are disposed of annually through HWRCs and bulky collection.[11] These are mainly from domestic sources, and the bulky nature of mattresses means that they are treated as bulky waste and collected either at HWRCs or 'special pick-ups'. The cost of a special pick-up varies between LAs, ranging from free to £51.50 for several items.[12] Both routes generally result in mattresses being sent to landfill, unless the LA has a recycling scheme in place. LAs have different approaches to waste management, some undertaking management themselves, and others contracting out to third parties. This offers the most consistent and reliable source of mattresses, but the mattresses need to be kept dry which can be difficult under these circumstances. This barrier is discussed later in the business case. The ease, ubiquity and cost of this service would appear to limit the possibility of a separate collection scheme as part of a recycling operation.

Retailer take-back arisings

Mattresses may also be disposed of via retailer take-back when a new mattress is delivered. Most retailers offer this option, but typically there is a charge to the householder for this service ranging from £25 to £40. Certain take-back schemes in some areas are tied into recyclers, particularly from the hospitality sector. However, most of the fee is

[9] Based on ONS data for the UK, and taking a *per capita* figure of 8.4% of the UK population for Scotland. Mattresses categorised as "other" have been excluded for the purposes of the business case. Source data is provided in Appendix II.
[10] Greater detail shown in Appendix I and Appendix II
[11] Information in Appendix II
[12] Information in Appendix II

absorbed by the retailer to cover the cost of this service or to generate profit, with only a small proportion passed on to any associated recycler due to the cheap cost of landfill as an alternative. One Scottish retailer indicated that about 10% of mattress sales involve collection of an old mattress[13]; another UK-wide supplier estimated 20%. The manufacturer Dreams estimates that approximately 7,500 tonnes (estimated 375,000 mattresses) are returned throughout the UK, though it is not certain what proportion of these are recycled at present, or with which geographical areas this is associated. Therefore the exact scale of take-back schemes is unclear, but estimated to be 320 tonnes or around 15,000 mattresses p.a. in Scotland.[14]

Commercial and public sector arisings

Other sources of mattresses outside the domestic sector may also offer opportunity, such as the NHS and care homes, the hospitality sector and prisons. However, these are more fragmented and irregular sources. In addition, organisations such as some prisons and hospitals have contracts with manufacturers which ensure the waste mattresses are removed as they are replaced, for instance through companies such as Carpenters which recycles its own mattresses.[15] Other schemes have been identified in the hospitality sector. For example, the Premier Inn chain of hotels disposes of an estimated 6,000 mattresses p.a. in the UK, with disposal handled by its supplier Hypnos. Although tie-in with sources such as this is possible, volumes from this sector are unlikely to be high enough to support a recycling operation alone.

Operational considerations with sourcing mattresses

One of the main issues associated with mattress disposal, considering their bulky nature, is transport. Mattresses are either treated alongside other bulky waste or have special schemes in place for their collection and disposal, such as retailer take-back. Transporting waste mattresses over long distances is generally avoided due to their bulk and low value,[16] so mattress recycling is reliant on a relatively local supply of waste mattresses. Suppliers are required to pay a gate fee to the recycling company, usually per mattress, as this is an alternative service to landfill. This acts as one of two income streams for the recycling operation.

Initially the most consistent and reliable supply of mattresses for recycling arises from LAs. If engaged correctly, LAs can supply a regular source of waste mattresses suitable for recycling. Competing with LAs and take-back schemes for collection is considered to be unfeasible due to costs associated with operation (transport and staffing) and advantages that retailer take-back and LA collections have. Other options could be considered to augment the supply if necessary; however, they are not viable on their own for Scotland.

3.1.1 Demand for materials

The capture of materials from mattresses drives the process by generating a recycling revenue standpoint, and is the second and critical income stream for the recycling operation. Mattresses consist of a variety of materials; the recycled materials are sold on to other end markets where they are re-processed into new products, or may be sold on for other uses such as energy from waste or landfill cover where no other option is available. For cost reasons landfill is avoided where possible when materials have been reclaimed from mattresses.

The average composition of a mattress is shown in Table 2.[17] The main contributors to the weight are steel and PUR foam: 29% and 25% respectively. In practice textiles are grouped together, as they are difficult to separate due to the construction of the mattress, and are therefore sold on to mixed textiles markets. 'Mixed textiles' accounts for 7.7kg or

[13] Personal communication, Laurie Robinson, Robinson's Beds
[14] Further information in Appendix II
[15] For example, Carpenters supply MOD mattresses of foam, and take these back to recycle into underlay at end-of-life – personal communication, 2012
[16] It is estimated that 1 standard cargo container can hold up to 90 mattresses or around 2 tonnes of mattresses
[17] This represents an average value and the composition of individual mattresses is likely to be substantially different to this.

36% of the mattress weight. Natural fibres, which include coconut fibres, sisal, jute, and hemp, are estimated to account for 1.6kg or 7.5% of the weight and are often included in the mixed textiles.

Table 2 Average mattress material composition

Material	Average mattress composition (kg)	Average mattress composition (%)
Steel	6.2	29%
PUR foam	5.3	25%
Cotton, non-woven	3.3	15%
Natural Fibres (e.g. coconut, sisal, jute)	1.6	7%
Felt	1.6	7%
Cotton, woven	1.4	6%
Wool	0.8	4%
Polyester, non-woven	0.8	4%
Latex foam	0.6	3%
Total	**21.4**	**100%**

Source: calculated from ONS PRODCOM, 2010 estimates and lifecycle assessment data (outlined in Appendix II)

Steel

The market for scrap steel is well established and will accept the steel springs isolated from the mattress. The value of this material is potentially around £200 per tonne when collected according the mattress recyclers and figures from WRAP.[18] However, the springs cannot be packed easily, making transport more difficult. This substantially reduces the value of the metal to around £80 per tonne, minus transport costs. Options for compacting the springs are available to increase the value; however, at present these are reliant on machinery which is expensive to purchase - for example a second hand compactor may cost in excess of £150,000. Assuming the maximum increase in steel value it is estimated that a throughput of approximately 50,000 mattresses p.a. is required to break even, based on a five year loan period. This has not been included as part of the business case.

PUR foam

Three markets exist for separated PUR foam. Recycling, energy from waste (EfW) and landfill cover (as part of mixed shredded materials). Recycling offers the highest value of these options, with markets varying depending on the source, quality and intended use. PUR foam from mattresses is typically used for re-bonding, with small pieces bound under pressure to form products such as carpet underlay or gym mats. A value of around £100 per tonne when collected was identified for post-consumer scrap. However, factors such as location and customer perception (particularly about hygiene) potentially limit the scale of this market, and it is not relied upon when developing this business case.

The two other markets offer lower value alternatives. Foam can be sent to EfW processing or resource derived fuel (RDF), with an estimated value of £34 per tonne. Alternatively it can be shredded, mixed with other materials and used as landfill cover, which is cost neutral as it avoids the cost of landfill. However, this option is not used as part of the business case below.

[18] More detail provided in Appendix III

Textiles
Mattresses contain a variety of different textiles in the tick and shell, outlined in Figure 1 highlighting the variety in textile types. Common materials found in the shell include non-woven cotton, non-woven wool, felt/flocking and other natural fibres (Table 2). Tick is usually made from woven fibres such as cotton, polyester and nylon.

The highest value for reclaimed textiles is associated with clean, high quality and separated types. However, evidence indicates that the textiles obtained from mattresses are often of low quality (short fibre length) and are not economical or possible to separate due to the stitching or bonding used between the different materials and sections. Therefore it has proved most effective to sell on mixed bundles of textiles according to all mattress recyclers interviewed. When sold as mixed textiles their market value is around £88 per tonne, and some materials in the mattress may have already been sourced from recycled mixed textiles. However, concerns were expressed from the industry about recycling through this route, mainly due to concerns over hygiene and cleanliness because of their previous use in mattresses. Washing was not viewed as cost effective by recyclers due to the low value of the textiles. These concerns have affected the ability of similar operations to sell on textiles to higher value markets.

Alternatively, these textiles are acceptable to lower value markets where they are can be sold to a broker for around £50 per tonne for use in automotive felts, where this source of textiles is considered acceptable. This value has been used for the income from the textiles stream as sales to other markets do not appear reliable, for example the composition is not consistent enough to be used in shoddy according to mattress recyclers.

It should also be noted that textiles which are sent to recycling markets need to be dry and baled to achieve the maximum value. It is also assumed that local markets within Scotland can be found for these materials, if transportation over long distance is required the value obtained for these materials is likely to be lower.

Other materials
For certain materials, specifically latex, no suitable high value recycling option was identified. Latex can be sent to EfW or used as landfill cover (as mentioned previously for PUR foam). Natural fibres in mattresses can also be separated from textiles (but are not always). Evidence from other mattress recyclers indicates that end markets for these materials are not established, reducing options for disposal. Where this is the case they will be sent to EfW to recover calorific value as the alternative is landfill.

Landfill
Landfill offers a simple and comparatively low cost disposal option for most of these materials. Landfill tax at present is £64 per tonne for non-hazardous waste, rising £8 p.a. for the next two years. In addition to this, a gate fee is charged which is £18 per tonne on average in Scotland.[19] Therefore values for landfill of material have been estimated at £82, £90 and £98 per tonne for 2012, 2013 and 2014 respectively.

3.1.2 Competition

Scottish operations
Within Scotland there is little direct competition from mattress recyclers. A social enterprise, SpringBack run by FEAT, operated in the Grangemouth area taking mattresses from Edinburgh and Falkirk until late 2011 when operations ceased. Some assets and contracts were taken over by Oran ES; who have now established a mattress recycling operation at their Kilbagie site near Grangemouth, Clackmannanshire where they have both wet and dry waste recycling operations. At the time of writing the precise details and scale of this operation are unclear. However, at maximum capacity it was stated that SpringBack processed 10,000-15,000 waste mattresses per year. More broadly across the UK, around 10 other organisations operate mattress recycling schemes, but none of these operate within

[19] WRAP, Gate Fees Report, 2011

Scotland at present. There are indications that an English-based mattress recycler is seeking to expand into Scotland, but full details are confidential at the time of writing. Existing Scottish and UK recycling capacity are described more fully in Appendix III.

Waste disposal routes
It is likely the main competition will come from waste management organisations disposing of mattresses through other routes such as landfill or mixed waste processing that are more cost effective, often as part of an overall waste management arrangement with LAs. Contracts differ from LA to LA, but vary from handling waste delivered to a site to collecting, processing and final disposal of waste. Landfill remains a cheap option for councils and other waste handlers; a typical mattress weighing 21.4kg would cost £1.75 to dispose of via landfill in 2012, rising to an estimated £1.93 and £2.10 in 2013 and 2014 based in rises in landfill tax.[20] This often limits the up-front gate fee that organisations are willing to pay to mattress recyclers despite the clear benefits over landfill, although others would pay more due to the environmental benefits. Some organisations will extract value from mattress materials as part of general waste handling, typically by shredding which allows the reclamation of steel. However, it is vital for the viability of the mattress recycling business to increase the gate fee above the landfill costs because of the additional environmental benefits which may be gained.

4 Operational plan

4.1 Processing

Several operational stages are required for the processing of waste mattresses once they are disposed of by the user. For this operation processing will be mainly handled manually as this offers the most cost-effective and efficient method of recycling mattresses on the required scale and with the equipment available (based on information gathered from similar scale operations, outlined in Appendix III).

An operation to reclaim the materials in end of life mattresses falls into five steps (Figure 2).

Figure 2 Steps for mattresses recycling

4.1.1 Sourcing

The first stage of this recycling process involves the transport of the mattress to the recycling site, either via an HWRC or other collection process as described in Section 3.1. Delivery to the site by the collectors is the most economic, due to the need for additional transport and a waste carrier licence. This infrastructure is also already established. This is also true for the separated materials that are collected by and sold on to materials end markets. Including these activities places an additional burden on the business; for example, extra staff and vehicles for collection and transportation are required. Evidence from similar operations shows that they have not attempted to compete with existing disposal and collection mechanisms.

[20] Based on a gate fee of £18 per tonne, and landfill costs of £64, £72, £80 per tonne for 2012, 2013 and 2014 respectively, and an average mattress weight of 21.4kg.

4.1.2 Checking and unloading

Mattresses arriving at the recycling site must be checked for suitability, as it is important that they are dry and unsoiled. This may require a change in the way LAs collect mattresses and store mattresses (e.g. collecting using covered rather than open-sided trucks), which would need to be agreed prior to commencement of recycling as part of any contractual conditions agreed with LAs or mattress suppliers. Accepted mattresses will be unloaded to the site, a fork lift truck being available to aid with unloading. Covered facilities for unloading are needed to avoid mattresses getting wet due to the weather, a point that should also be considered when loading separated materials later in the process.

4.1.3 Mattress deconstruction

Mattresses will be stored on site before deconstruction when the materials are separated into types (i.e. steel, PUR foam). This process is conducted by hand, using knives and other suitable cutting implements. Manual deconstruction of mattresses involves the separation of materials through slicing with a knife by hand and manual strength to allow separation of the tick, core and shell materials (stitched components are left together as separation is too difficult). A semi-skilled operative working alone can process approximately 6-8 mattresses per hour using this method. Using operatives to undertake this activity with knives allows greater flexibility for the different types and construction of mattresses. First the operatives separate the outer tick from the inner materials in the mattress by slicing open the top of the mattress. This provides access to the inner shell and core. Once these inner materials are removed, they can be sorted into type by hand, using large cages or equivalent to keep materials separate. Core materials will be separated from others as far as is practical and placed into separate areas. Textiles from the tick and shell will be collected together, with no further sorting taking place.

Further processing is required for some of the materials, particularly the textiles which require baling before being sold on. Based on information gathered from recyclers, it is assumed that pairs of operatives will be employed. Of these, one will deconstruct the mattress, sorting materials during the process; the other will handle mattresses and materials, and any materials processing required such as bailing.

4.1.4 Separation, processing and distribution

The different materials will then be stored under cover before being collected by materials recyclers. One operative will supply another with a stream of mattresses and take away separated materials, ensuring that mattresses are continually being deconstructed to achieve the highest processing capacity. Once separated, the materials will be sold on and collected by end market actors. These markets are assumed to be local and therefore will pay the prices for materials outlined below. If longer distance transport is required the price paid for materials is likely to be lower.

4.2 Equipment

Manual deconstruction has been identified as the most appropriate method for deconstructing mattresses in this operation. When compared to other options such as mechanical processing, adopting simple manual deconstruction provides a more flexible and reliable method of mattress deconstruction, and on a scale that is appropriate for the volumes of mattresses. Additionally it avoids the need for large capital expenditure at start-up or during operation.

Various mechanical options are available which are designed to increase the efficiency of mattress deconstruction, ranging from a fully automated system capable of sorting and fully processing mattresses to general waste processing machinery. These functions include separating the tick from the internal mattress, and compressing springs using compactors; these are outlined in Appendix I. Some pieces of equipment are available commercially. Others are bespoke pieces of equipment and have been developed in-house by businesses. These provide an indication of the pathway other businesses have followed to improve efficiency. However, none were viewed to be cost-effective and reliable based on information gathered, and often they were not an improvement on standard waste processing routes. For example, the capacity of a fully automated system is 190,000 mattresses per year, more than is reasonable to collect within a localised geographical area of Scotland; and evidence from recyclers has shown that the machinery is

unreliable due to problems with bed-springs jamming the equipment or blades becoming blunt. In addition, fully mechanical processing routes often shred the materials entirely, leading to a reduction in the value of materials, and a more marginal environmental benefit.

4.2.1 Equipment for operatives

The main piece of equipment used by operatives to deconstruct mattresses is a strong utility knife with replaceable blades; these allow the mattresses to be cut up into pieces quickly and efficiently. Other equipment may be utilised as the business is developed and the opportunity for optimising the deconstruction process is available. For example, the use of hand-held power tools may prove effective for deconstruction due to their low cost, the ease of replacing parts and their simplicity of use.

Personal protective equipment (PPE)

Suitable safety equipment must also be provided for the operatives to ensure that they are safe in the working environment (health and safety is discussed in more detail in section 4.5). Key items of safety equipment include heavy-duty safety gloves, safety boots, high visibility vests, goggles and dust masks. These provide protection in the working environment from hazards such as the knife blades, mattress springs and fork lift truck movement.
The annual cost of this equipment is estimated at £152 per operative. To allow for staff turn-over and replacement of equipment during the year this figure is doubled to £304. It is assumed that this equipment will be replaced annually for each operative.

4.2.2 General equipment

Other pieces of equipment are also required; forklift truck, pallet trucks, pallet racking, work benches and a textiles baler. Wheeled storage cages for the materials are also useful for the separation and transfer purposes. Indicative costs are provided in Table 3. A forklift truck will be used for unloading and transporting mattresses and moving materials around the facility. The pallet trucks serve the same purpose - though less efficiently, but do not require specialist training. Work benches will be used during the separation of mattress materials, to raise the height of the mattresses. Pallet racking will be used to store materials on pallets before collection. A baler is required to process the textiles, baling them so they can be sold on to secondary markets.

Table 3 Indicative costs of deconstruction equipment

Equipment	Units Required			Purchase price per unit (New)	Lease per unit (New) (pcm, 3yr agreement)	Purchase price per unit (Second hand)
	Year 1	Year 2	Year 3			
Baler (textile)	1	-	-	£8,500	£272	£5,000
Forklift truck (2,000kg capacity)	1	-	-	£12,000	£370	£3,000-£7,000
Operative equipment	4	4	8	£102	---	---
Pallet racking (w 2710mm x d 900mm x h 3500mm)	2	-	2	£400	---	£200
Pallet truck	1	-	-	£250	---	£100
Storage cage	4	-	4	£100	---	£50
Work Bench	2	-	2	£250	---	---

4.3 Site location and requirements

Site location

The location of a mattress recycling facility is highly dependent on a consistent supply of mattresses, which are comparatively expensive to transport long distances due to their bulk. LAs have already been highlighted as the most appropriate source of mattresses and can provide a large supply of mattresses within a geographical area. An estimate of mattress arisings in each LA shows that the areas around Aberdeen, Glasgow and Edinburgh have the highest densities of waste mattresses (Table 4).[21]

Table 4 Areas of high arisings of waste mattresses

Population Centre	Local authorities	Total area (sq miles)	Estimated mattress arisings
Aberdeen	Aberdeen City, Aberdeenshire	2,509	33,901
Edinburgh	City of Edinburgh, West Lothian, Midlothian, Falkirk, Fife	1,030	85,787
Glasgow	Glasgow City, Renfrewshire, North Lanarkshire, Inverclyde, West Dunbartonshire, East Dunbartonshire, East Renfrewshire, South Lanarkshire	1,590	121,085

However, the Glasgow area is deemed the most suitable as it has three geographically small LAs all with high population densities and therefore mattress arisings; Glasgow City, Renfrewshire and North Lanarkshire, as well as several others close by, as described in Table 5.

Table 5 Waste mattresses arisings in the Glasgow region

Local authorities	Total area (sq miles)	Estimated mattress arisings	Local authorities	Total area (sq miles)	Estimated mattress arisings
Glasgow City	68	39,625	East Dunbartonshire	68	7,260
North Lanarkshire	469	22,314	West Dunbartonshire	68	6,085
South Lanarkshire	686	21,942	East Renfrewshire	65	6,073
Renfrewshire	102	11,979	Inverclyde	64	5,807

Therefore the region around Glasgow provides the best central area from which to base operations, with potential to grow in the future. In addition Oran ES are commencing recycling operations using mattresses from the Edinburgh/Falkirk area, though the scale of this activity is unclear at present. It appears unlikely that there is capacity for two recyclers of a reasonable scale within one region. Aberdeen City and Aberdeenshire are ruled out initially, as the number of mattresses is relatively small for the larger area compared with other regions; therefore it is felt other locations will be more suited for start-up.

Site requirements

The facilities required for processing mattresses are relatively basic, with no specialist amenities needed even if a more automated approach is taken in the future. A manual mattress recycling operation requires a light industrial (or

[21] Greater detail for each LA is provided in Appendix I, with a map showing the areas of high arisings, particularly around the central belt, and further supporting data is provided in Appendix I and supporting evidence in Appendix II.

equivalent) warehouse with access for unloading mattresses and loading materials, and 3-phase power for heavy machinery. To be most effective the whole process must be conducted under a roof to avoid the mattress materials getting wet and reducing the value of the textiles. Space is therefore required for four functions; storage of incoming mattresses, processing mattresses on work benches, storage of mattress materials, office and amenities. Premises of this type in or close to large population centres can be leased at around £3-£7 ft^2 p.a. Elsewhere lease prices drop to £2-£5 ft^2 p.a. further away from city centres and industrial areas. Maintaining low rental costs is critical to avoid managing overheads and the viability of the business. Locations close to key motorway links, such as at the east end of Glasgow, offer strategic places for delivery and distribution, and this area has empty warehouse capacity at present. For the purposes of the business model a costs of £3 ft^2 is used, excluding business rates.

Based on information gathered from other recyclers, it is estimated that $1ft^2$ of floor space provides capacity for processing approximately 2.5 mattresses per year for the scale of manual processing proposed. Based on evidence of minimal predicted processing capacities, premises of at least 8,000 ft^2 will be required for the first two years, allowing four operatives to work simultaneously. This allows capacity for 18,500 mattresses p.a. or around 80 mattresses per day for up to Year 2.

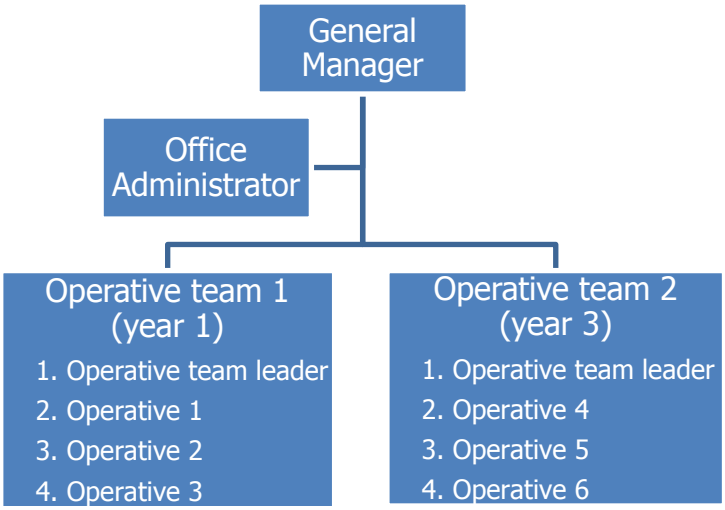
Larger premises will be required in the third year as capacity increases. It is estimated that a 16,000 ft^2 site will be needed at this point to double mattress processing capacity to 36,000 mattresses p.a.; however, this would be reviewed once this stage is reached.

4.4 Human resources

Mattress recycling is broadly split into two functions; management and administration, and operatives for processing mattresses. One lead operative will be assigned per group of four operatives. Figure 3 shows an organogram of the staff in the organisation.

The General Manager will be required to set up and run the business. Before the start-up of recycling operations the General Manager will organise locating premises, purchasing of equipment, recruitment, mattress supply, arranging buyers for materials, and applying for relevant permits. Once the organisation is running, the General Manager will take on responsibilities such as staff management and training, development of new mattress and materials markets, and other activities associated with day-to-day running of the business.

Figure 3 Organogram of mattress recycling staff



A part-time Office Administrator will required at start-up, and will have responsibilities for day-to-day paperwork, book keeping, payroll, supporting management and other administrative tasks. As the business expands the administrative support will expand to full time in Year 3.

Manual operatives will conduct the physical process of mattress recycling. It is estimated that one operative can process a maximum of around 12,400 mattresses in a year.[22] However, for each operative processing the mattresses into separate materials, one other will be required to manage the flow of mattresses (unloading, sorting, and transfer) and materials once separated (transferring, consolidating and baling). Initially, two operatives will be hired to establish the processing system. This will be expanded to four operatives three months into Year 1 and to be maintained through Year 2. One of these operatives will act as team leader and be trained to use the forklift truck and other machinery. A further operative will undergo forklift truck training to provide cover for this role. Another team of four will be employed at the start of Year 3 once the business has been established and moved to larger premises with similar training requirements

Training
External training will be provided for designated forklift truck operatives to ensure safe use and cover running and maintenance issues. All operatives will be trained for manual handling. Other training, such as the process for deconstructing materials, will be handled on the job.

First aid training and fire safety will also be provided to one full time employee, who will be responsible for this within the work place. All employees will receive internal health and safety training specific to their function within the organisation. This is particularly important for the operatives in the warehouse due to the risks such as fork lift trucks, use of sharp blades and materials.

No further specific training for the other staff is envisaged at the start of the business.

4.5 Health and safety

Monitoring and meeting health and safety requirements are critical for the business, and this will be the responsibility of the general manager. As part of these responsibilities the general manager will:

- be the designated health and safety contact internally and externally, this will also be the designated "Responsible Person" for interaction with the HSE;
- develop the company safety policy which identifies hazards and states how to manage risks;
- maintain an accident register to keep record of incidents in the work place, and report any incident which meets with RIDDOR[23];
- ensure a poster displaying health and safety laws must be put on display for employees to read;
- ensure that the liability insurance in case of injury or illness caused by the work is up-to-date and covers all activities undertaken[24];
- ensure unobstructred routes to fire exits and ensure these are appropriately marked; and
- keep up-to-date with, and inform employees of, other health and safety considerations include working temperature, lighting, eating and resting facilities and fire alarms. These fall under general guidelines for businesses rather than specific needs for mattress recycling and should not present additional costs to the business.

A first aider and safety officer will be identified for the site as appropriate, and first aid kits made available.

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[22] Based on 7 mattresses processed in an hour, working 7.5 hours a day for 47 weeks a year.
[23] http://www.hse.gov.uk/riddor/index.htm
[24] More information can be found here - http://www.hse.gov.uk/scotland/

Several aspects of the working environment also require consideration:

- Manual deconstruction of mattresses involved the separation of materials through slicing with a knife by hand, and the following protective equipment is required:
  - dust masks (worn whilst moving mattresses about, and also when cutting);
  - heavy duty gloves (for wear when using blades); and
  - eye goggles (worn when breaking apart mattresses).
  - Internal health and safety training will also be provided to ensure safe use, as well manual handling training.

- The working area will involve machinery and materials handling equipment. Safety boots and high visibility jackets should be provided. The use of fork lift trucks requires that 'traffic' routes are set up for pedestrians and forklift trucks within the warehouse. A code of practice is also published for the use and maintenance of forklift trucks which the driver will be familiar with.[25] The designated forklift truck driver will undertake the relevant training to ensure safe use and cover safe running and basic maintenance; this may be a refresher course or basic training depending on experience.

- Processing mattresses involves lifting and moving of heavy objects. Correct manual handling procedures and techniques will be put in place. Operatives will attend a manual handling course to ensure they are working safely.

4.6 Waste management legislation[26]

Several requirements must be met associated with waste management legislation. These include:

- Registration with SEPA to gain a waste management licence. There is a fee associated with registration for some activities. Recycling of mattresses should be exempt from this charge due to the recycling of baled textiles, steel and other materials.[27]
- Registration as a waste carrier or broker due to the way material is handled.[28]
- Waste transfer notes will also be required for incoming and outgoing shipments, and this can be implemented on a long term basis if occurring regularly with the same supplier.[29]

Overall, the necessary requirements identified are deemed relatively straightforward to implement, and do not present a significant barrier to setting up a business.

4.7 Business development plan and financials

4.7.1 Development plan

The section below outlines the activities required at each stage of the business in the first three years and describes the possibilities for development after an initial three year period.

Year 1 (Months 0-3) – Business set-up

The activities below will be conducted by the general manager in advance of recycling operations commencing.

Sourcing mattresses and end markets - Two LAs will be targeted to supply mattresses for the initial phase to ensure a steady supply, with a view to starting deliveries as soon as the site is ready. Contracts will be put in place with

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[25] http://www.hse.gov.uk/workplacetransport/personnel/lifttrucks.htm
[26] This information is accurate as of August 2012; however legislation and regulations may change over time and should therefore be confirmed prior to start-up.
[27] http://www.sepa.org.uk/waste/waste_regulation/application_forms/waste_management_licence.aspx
[28] http://www.sepa.org.uk/waste/waste_regulation/application_forms/waste_carriers_and_brokers.aspx
[29] http://www.business.scotland.gov.uk/bdotg/action/detail?itemId=1079432027&site=202&type=RESOURCES

these LAs (or with their contracted organisations with the support of the LAs) to ensure a secure supply of mattresses at volumes required by the business. This will also outline conditions for delivery and secure supply over several years to provide confidence in longer-term operation. It is critical that the gate fee is set at the correct level at this point on a long term basis, to underpin the business. Local end markets will be found for materials to reduce the impact of transport, both for recycled steel and textiles. Relevant permits and licences will be applied for and obtained. A business development and marketing budget of £1,000 is available in the first year to support these activities.

Business setup and staff – Before starting recycling operations, premises will be found and a lease agreed. Key pieces of equipment - such as personal protective equipment, a fork lift truck, a pallet truck, pallet racks, textiles baler, and cages – will be sourced to ensure availability as close to the start-up date as possible. An 8,000 ft^2 premises will be leased on a short-term basis in the targeted region. Insurance will also be put in place for the start of the operations. Recruitment will also take place to ensure staff are available for the start of recycling operations. The estimated capital outlay for these expenses is below £15,000.

Year 1 (Months 3-12) – Establishing of recycling operations

Once the business is set up the remainder of the first year is used to establish the mattress recycling operation, demonstrate and optimise deconstruction, and put systems in place for the business. This will lead to the generation of income from gate fees and sales of materials. In total 10,000 mattresses will be processed this year, with a staged processing start-up period to allow for delivery, processing and materials collection systems to be established with contracted parties and optimised. In this phase the General Manager will be mainly involved in the initiation of staff and recycling operations, and managing the contracts previously negotiated.

Initially processing will be phased, with two operatives (one a team leader) achieving an estimated 50% processing capacity rising to 75% capacity after three months. This provides scope within the plan for initiation, training and optimising the processing system and improvements in staff efficiency. A further two operatives will start later in month six of the first year, with the same phased processing capacity predicted. This will lead to around 10,000 mattresses being processed in a year. The operatives will be supported by a part-time (0.5 FTE) Administrator and a full-time General Manager.

The major costs in this stage are associated with labour, property leasing (including business rates) and others associated with running costs.

Year 2 – Preparing for growth

In Year 2 no major changes are made to the business, with the aim of establishing stability, building confidence and credibility, and providing a foundation for growth in later years.

Mattress processing capacity will remain constant through Year 2 to avoid the need to change premises causing disruption, and provide the General Manager with resource to prepare for expansion in Year 3. The same staffing levels are kept throughout the year. The number of mattresses processed increases to 18,500 as no staff need to be phased in. Mattresses will continue to be sourced from existing contracted parties at the same rate as the end of Year 2.

The major costs in this year are associated with labour and property leasing (including business rates).

During the year the General Manager will develop existing or new contacts, to help establish a greater supply of mattresses and end markets for the following year, leading to expansion into larger premises. To spread risk, alternative mattress sources will be sought such as private organisations (particularly in the hospitality sector and retailer take-back), and marketing will be focussed on these organisations as well developing new sources from LAs. This will help support and expand on the core supply of mattresses provide by the LAs.

Year 3 – Scale up of operations

Year 3 will provide a significant growth phase with a doubling of mattress processing capacity, reaching the breakeven point. This will be supported by the deconstruction of 34,200 mattresses from local sources, including some private sources if identified through earlier marketing and business development activities. Contracts with additional nearby LAs will be sought with the evidence of two years' successful operation to demonstrate the viability and support of other LAs. The location chosen in the Glasgow region will offer several possibilities at this stage.

The expansion in processing capacity is supported by moving to larger premises in the same area, doubling the number of operative staff to eight, and increasing the administrative support to full-time. New premises will be leased and occupied with similar facilities and appropriate location; it is assumed that two weeks' production will be lost and capacity has been reduced to take this into account. The new premises will be around twice the size of the previous location (16,000 ft^2). New operatives will be trained as before and phased in to full capacity over three months. Additional equipment will be bought in the form of cages for the materials processing.

Beyond Year 3

In Year 3 a strategy for further expansion will be developed based on learning and the information gathered during the operations. Continued development will be targeted after Year 3 to increase the number of mattresses processed and the profitability per mattress. Options such as opening another site (alternative strategic location), adopting a two shift system, or purchasing machinery for enhancing efficiency of processing (such as compacting machinery for springs) will be assessed. Decisions will be based on the local availability of mattresses and potential for capacity increase, potential for markets for materials at other locations and interest from sources.

4.7.2 Expenditure

Expenditure has been calculated on the following assumptions:

Salaries

- The General Manager will receive a yearly salary of £30,000 and the Administrator £10,913 *pro rata* (i.e. minimum wage).
- Operatives will receive an annual salary of £10,913 (i.e. minimum wage), the operative team leaders £15,000.
- Employer National Insurance contributions have been included assuming start-up at the start of the financial year. The 2012-2013 rate of 13.8% on earnings over £144 has been applied.

Salaries are the main expense of this business, and need to be kept low due to the comparatively low income received from gate fees and sale of materials.

Facilities

- A leasing rate of £3 per ft^2 per year has been assumed before business rates are applied.
- Business rates are added at 40.7p for each pound of rateable value.
- Utility costs have been estimated based on similar operations.
- It is estimated that 2.5 mattresses per ft^2 can be processed per year, based on information provided by similar UK operations.

Capital expenditure (start-up)

- Forklift truck (second hand) - £5,000.
- Textiles baler (second hand) - £5,000.
- Warehouse cages (x4) - £200 (total).
- Pallet truck (x1) - £100.
- Pallet racks (x2) - £400 (total). This represents capacity for 16 EUR pallets (800mm x 1200mm)

Other costs

- Personal equipment costs have been estimated from equipment prices; these are estimated at £304 per annum per operative.

- Training costs are estimated from certified schemes; for example, forklift truck training at £300 and/or manual handling training at £100.
- Other costs include IT and phone equipment and service contracts, and other consumables, bank charges, insurance and maintanence. These have been based on reasonable estimates for a business of this size.
- Marketing and business development have been allocated a budget of £1,000.
- Legal costs of £1,000 p.a. are assumed for Year 1 and £500 for Years 2 and 3. This is to cover costs associated with contractural costs for suppliers and materials buyers.
- A small contingency fund of £1,000 has been included each year to cover unforeseen expenses; for example, employment agency or legal fees or unexpected equipment failure. This represents around 1.5% of year one income.

4.7.3 Income

Projected income is based on the following assumptions:

Mattresses processed
The number of mattresses processed is expected to follow the following growth pattern; Year 1 – 10,000, Year 2 – 18,500 and Year 3 - 34,200. Initially these will be sourced from LAs in the Glasgow region where the mattress recycling operation is based; expanding to other LAs and private sources once the business is established and shown to work effectively.

Gate fees
Gate fees are the main source of income for this operation. Evidence suggests than an average gate fee of between £4 and £5 per mattress is acceptable to local authorities and other collection schemes at present. However, initial analysis showed that this charge is insufficient to sustain a business based on the details outlined and assumptions made – the processing could not be performed most cost effectively and the value of materials could not be increased reliably. Therefore a higher gate fee of £6.25 has been used to demonstrate the increase in income required to make this business viable. This allows for a breakeven point in year two, 10%-15% profit in year three and a positive cumulative net cash flow targeted in the following year. It is also assumed that the gate fee increases in line with landfill tax in coming years, to £6.42 in year 2 and £6.59 in year 3. This seems reasonable due to the increasing costs of landfill; alternatively it could be kept constant over the 3 years to potentially increase attractiveness. The gate fee may be negotiable to reach these higher values over the three years depending on source and number of mattresses received. For example, this could be partially funded by LA charges for bulky uplift which range from free to £51.50 for multiple items. Charges are also made for retailer take-back schemes, typically in the region of £25 to £40, however evidence suggests that this money goes to support retailers and distributors rather than being available to fund other parties.

Materials values
The sale of materials to end markets will represent a smaller income stream compared to the gate fee using this model. Several scenarios were modelled for the value of materials collected from the recycling site, based on different fates of materials. These are shown in detail in Appendix I. For the purposes of the business case it is assumed that the scenario outlined in Table 6 is realistic and is viable in the long term, leading to an income of £7.40 per mattress.

Table 6 Income from mattresses in year 1 (Scenario 3)

	Material fate	Income per mattress
Steel	Scrap (uncompressed)	£0.50
Textiles	Baled (low value)	£0.47
PUR foam	EfW/RDF	£0.19
Natural fibres	EfW/RDF	£0.06
Latex	EfW/RDF	£0.02
Total materials		**£1.15**
Gate fee		**£6.25**
Total per mattress		**£7.40**

These scenarios assume that local markets are available for materials, which may not be the case (particularly for textiles). Therefore the actual value received for materials may be lower due to any additional transport costs associated with more distant end-market actors.

4.7.4 Three-year cash flow projection

The forecasted three-year cash flow projection is shown over, based on the growth model and assumptions described above; mattresses processed and tonnage is also shown. Here it is assumed that no tax can be reclaimed there are no other business activities.

4.7.5 Three-year profit and loss

The 3 year finances and profit and loss accounts for the first three years of operation are shown in the tables which follow; these are based on the growth model and assumptions described above. This also assumes that there is sufficient annual investment allowance available within the business for the initial capital expenditure, and that there are no other parts of the business generating a profit.

These figures show that in the first year the business will not be profitable, mainly due to low income due to initiation of operations and capital expenditure. The business as described will come into slight profit in year 2 as processing capacity increases. Year 3 shows a good profit after a large growth in mattress processing capacity. Debts incurred in year 1 mean that the business does not reach breakeven in terms of cumulative cash flow by the end of year 3. However the debt is significantly reduced and a similar performance in the year following year 3 would lead to a positive cumulative cash flow.

3 Year Finances			
Cash Flow	**Year 1**	**Year 2**	**Year 3**
Total Receipts	**£ 74,195**	**£ 140,116**	**£ 264,843**
Gate fees:	**£ 62,656**	**£ 118,815**	**£ 225,464**
Materials:			
Steel	£ 4,972	£ 9,179	£ 16,970
PUR Foam	£ 1,913	£ 3,531	£ 6,528
Textiles	£ 3,860	£ 7,125	£ 13,172
Latex	£ 217	£ 400	£ 739
Natural Fibres	£ 577	£ 1,066	£ 1,971
Total Materials	**£ 11,539**	**£ 21,302**	**£ 39,379**
Capital Expenditure	**£ 11,200**	**£ -**	**£ 700**
Operating Expenditure	**£ 129,582**	**£ 134,129**	**£ 228,923**
Total Salaries & NI	£ 83,054	£ 88,745	£ 144,855
Rent	£ 24,000	£ 24,000	£ 48,000
Business Rates	£ 9,768	£ 9,768	£ 19,536
Utilities	£ 5,000	£ 5,000	£ 8,000
Maintenance	£ 500	£ 500	£ 500
Personal & other equipment	£ 760	£ 1,216	£ 2,432
Office Supplies & ICT	£ 1,000	£ 500	£ 500
Business development & Marketing	£ 1,000	£ 1,000	£ 1,000
Travel	£ 500	£ 500	£ 500
Training	£ 1,000	£ 200	£ 700
Bank Charges & Insurance	£ 1,000	£ 1,200	£ 1,400
Legal Costs	£ 1,000	£ 500	£ 500
General Expenses & Contingency	£ 1,000	£ 1,000	£ 1,000
Tax	£ -	£ -	£ -
Net cash flow	(£ 66,587)	£ 5,988	£ 35,220
Cumulative net cash flow	(£ 66,587)	(£ 60,599)	(£ 25,379)

Profit and Loss	Year 1	Year 2	Year 3
Total Receipts	**£ 74,195**	**£ 140,116**	**£ 264,843**
Gate fees:	**£ 62,656**	**£ 118,815**	**£ 225,464**
Materials:			
Steel	£ 4,972	£ 9,179	£ 16,970
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Utilities	£ 5,000	£ 5,000	£ 8,000
Maintenance	£ 500	£ 500	£ 500
Personal and other equipment	£ 760	£ 1,216	£ 2,432
Office Supplies & ICT	£ 1,000	£ 500	£ 500
Business development & Marketing	£ 1,000	£ 1,000	£ 1,000
Travel	£ 500	£ 500	£ 500
Training	£ 1,000	£ 200	£ 700
Bank Charges & Insurance	£ 1,000	£ 1,200	£ 1,400
Legal Costs	£ 1,000	£ 500	£ 500
General Expenses & Contingency	£ 1,000	£ 1,000	£ 1,000
Finance Cost	**£ 2,800**	**£ 2,800**	**£ 2,975**
Depreciation (over 4 years)	£ 2,800	£ 2,800	£ 2,975
Operating Profit	(£ 58,187)	£ 3,188	£ 32,945
Capital Allowance (100% year 1)	£ 11,200	£ -	£ 700
Tax (20% - small profits rate)*	£ -	£ -	£ -
Net Profit after tax	(£ 66,587)	£ 5,988	£ 35,220

* This is offset first year losses, therefore no tax is paid in the first 3 years.

The main factor which can influence the economic viability of the operation is the value received for each mattress, as operating and capital costs are unlikely to be reduced. An analysis of the income per mattress compared to the expenditure is shown in Table 7.

Table 7 Estimate of breakeven value of mattresses based on expenditure

Breakeven point per mattress (based on expenditure)	Year 1	Year 2	Year 3
Mattresses	10,000	18,500	34,200
Expenditure	£140,782	£134,129	£229,623
Actual cost per mattress processed	£14.04	£7.25	£6.71
Gate fee (increase based on increase in landfill tax)	£6.25	£6.42	£6.59
Total estimated income per mattress	£7.40	£7.57	£7.74
Profit/loss per mattress	-£6.64	£0.32	£1.03

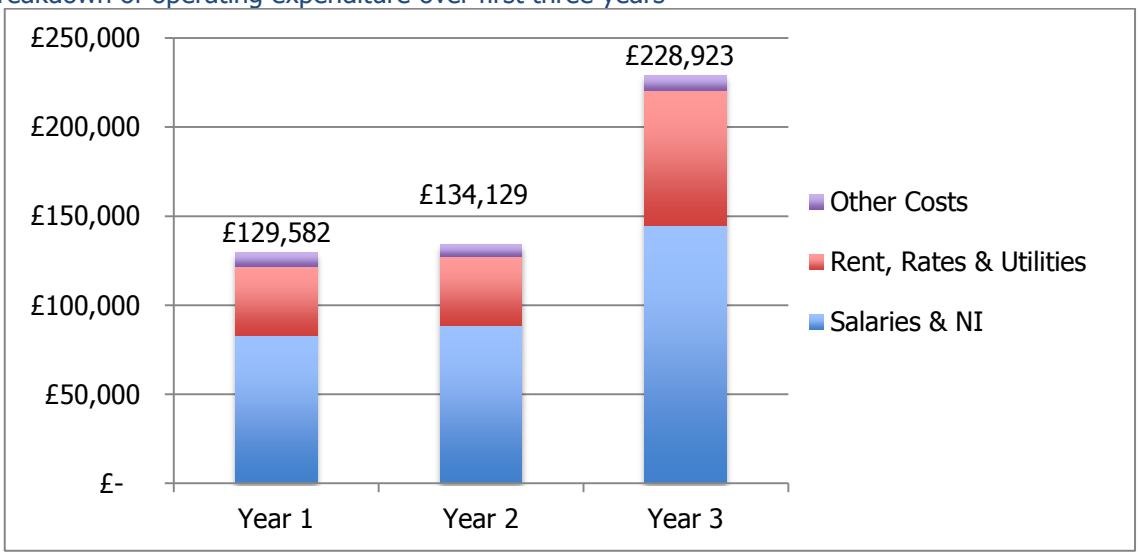
Initially the loss per mattress is high, due to capital costs and low processing capacities in Year 1. Increasing the processing capacity through Years 2 and 3 reduces the loss per mattress, and breakeven is achieved in year 2 and

profit extended in year 3. However, these figures suggest that a small difference in income per mattress would have large impacts on the viability of this business. The most sensitive factor is variations in gate fees, which the business is heavily reliant on as higher income from materials cannot be guaranteed. The impact of changing the gate fee is explored in section 4.8.6.

4.7.6 Sensitivity analysis

Operating expenditure
A breakdown of expenses is shown in Figure 4. The overall operating expenditure will remain fairly static over the first two years, rising in the third year.

Figure 4 Breakdown of operating expenditure over first three years



The largest expenses are associated with employment and leasing costs. It is assumed that staff will be found that will work at minimum wage, with no increases over the first three years. However, if the minimum wage is changed the expenditure will be affected. For instance, if it is raised by roughly 2% (a similar increase to that seen in October 2012), staff costs will go up by around £1,000 in Year 2 and £2,000 in Year 3.

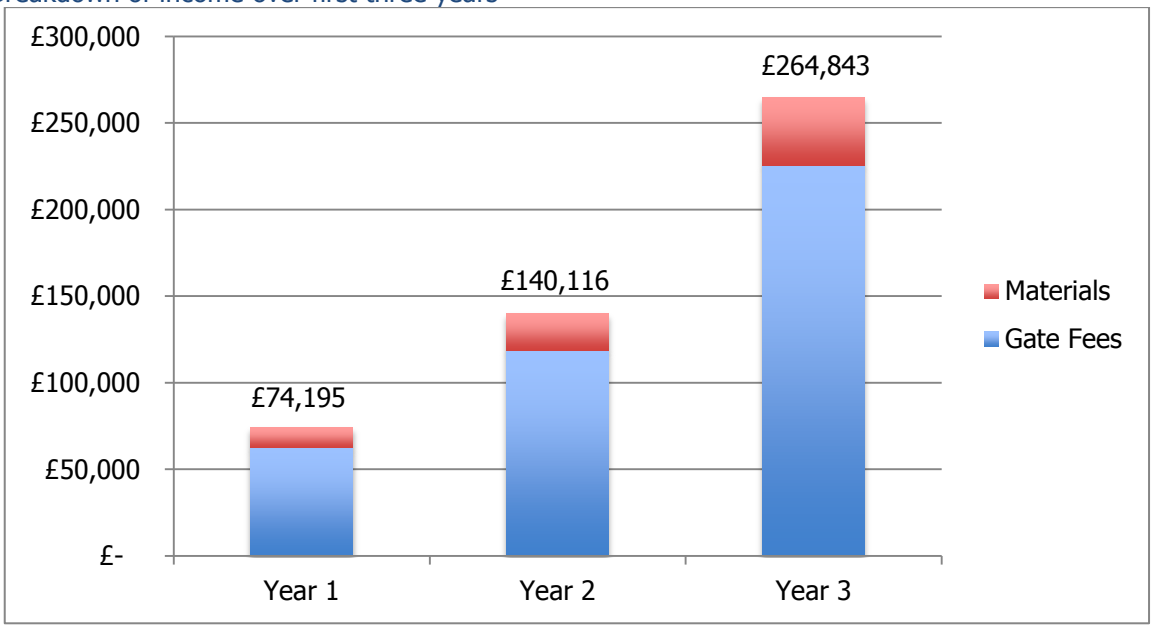
Leasing costs are critical as they impact on the business rates. Increasing the lease for an 8,000 ft^2 property by 5% will increase the cost of rental by £1,200 and increase the business rates by approximately £500. It should be noted that some flexibility may also be needed in the size of the property if an 8,000 or 16,000 ft^2 facility is not available at the correct times. Additional capital expenditure may also be required at this point; the largest cost would be associated with the purchase of an additional fork lift truck, which is estimated to cost £5,000. Other costs are likely to be much lower (e.g. cages and racks). These smaller costs could be absorbed by the contingency costs if required.

Income
Using these figures a breakdown of income can be produced for the first three years (Figure 5). Income is most sensitive to the gate fee paid for each mattress which has been set at £6.25 rising to £6.42 and £6.59 over subsequent years. However, this represents a value over 3 times the landfill cost (excluding other costs of wear and tear on machinery and staff costs). Landfill costs are set to rise in the coming years, but not significantly enough to offset this price difference.[30] Therefore this model is reliant on the willingness of councils and retailers to pay above minimum cost

[30] Landfill costs will rise by £8 a tonne per year until 2014, for an average mattress this is an increase of around 17p.

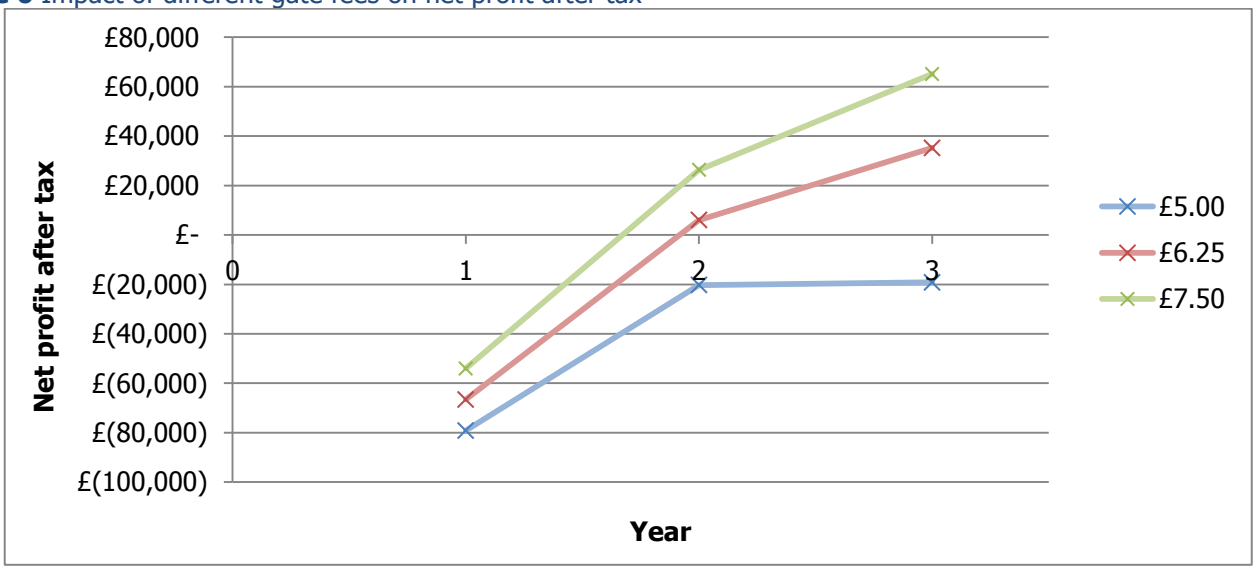
to achieve environmental benefits. As priorities with waste handling and other spending change, this price may be difficult to sustain.

Figure 5 Breakdown of income over first three years



Based on information gathered above it unlikely that a processing operation will be feasible based on a gate fee which is equivalent to landfill tax costs or even a gate fee seen elsewhere of around £5. Figure 6shows the impact on net profit after tax when lower gate fees are put in place.

Figure 6 Impact of different gate fees on net profit after tax



As shown by the figures above, if a baseline gate fee of £6.25 is used the business reaches the breakeven point in the second year and produces a reasonable profit in year 3. A lower gate fee of £5 leads to losses in all years and the business never breaks even. If a higher gate fee of £7.50 (or £8.65 total income per mattress) is used, the business breakeven in Year 2, with a positive net cash flow in Year 3. A positive cumulative net cash flow is achieved in year 3, in contrast to the £6.25 scenario which never reaches this stage.

Income from materials is also important. However, as it is distributed over several markets it is less sensitive to one particular materials stream. Based on the modelling above, the most critical markets are steel and textiles, which account for 43% and 33% of the income from materials respectively. Fluctuations in the prices of these materials will clearly impact on the business. Additional costs may also be incurred if transport of materials is required, which will increase costs further due to need for transport, drivers and appropriate licences. Given the value of the materials this is not deemed viable.

4.7.7 Funding options

Several possibilities exist to reduce either the up-front capital expenditure of setting up the business, or to lower on-going costs. Some examples are provided below.

Within Scotland funds are available for businesses developing new recycling processes; those available from Zero Waste Scotland are the most relevant.[31] Based on previous schemes, suitable funds could become available which could be used to cover some of the capital expenditure associated with start-up, thus reducing losses in the first year.[32]

To minimise on-going expenses several options could be considered. The greatest outgoings are associated with leasing a property (including business rates) and staff costs. Schemes are available to small business to reduce leasing costs by offering relief to rates for small businesses. However, the size of the site required precludes applying for relief under the current Small Business Bonus Scheme in Scotland.[33] None was identified at present for the area proposed for the business.

[31] http://www.zerowastescotland.org.uk/category/what-we-offer/funding
[32] http://www.zerowastescotland.org.uk/recyclinginnovationfund
[33] http://www.scotland.gov.uk/Topics/Government/local-government/17999/11199/Scheme

4.7.8 SWOT analysis

Strengths	Weaknesses
Offers alternative to landfill for waste mattresses. Waste mattresses will always be available and LAs could offer a reliable supply. Mattresses have relatively consistent composition and contain materials with value. Simple set up procedure for a new plant, with no specialist or expensive equipment required. The process described maintains the value of materials compared to shredding or similar processing ensuring material values are maintained. This model can be replicated at different sites where enough capacity exists, allowing expansion to new regions.	More costly than alternative disposal options, particularly landfill. Highly reliant on gate fees to cover cost of business, lower gate fees decreases the economic viability. Continuing acceptability of materials to end markets, particularly textiles. Existing mattress supply reliant on a limited number of third parties in a geographical area. Site scale up is difficult due to logistics and arisings, and relative lack of economies of scale for manual processing. Scope for large scale automated processing limited. Poor economies of scale for the processing operation.
Opportunities	**Threats**
Little recycling occurring in Scotland at present, therefore no competition however, need to understand why the business failed. Ties in with policy aims of Scottish Government, particularly reducing landfill waste and recycling materials. Opportunity to improve environmental impact of waste, and limit volume of waste sent to landfill. Simple to set up for established organisations with sustainable operations. Prospect to work with retailer take-back schemes to increase income and quality of mattresses collected. Increasing the pressure on LAs to improve quality of collection service and consequently the quality of mattresses. This may lead to funding for collection services. Targets to reduce the amount of waste sent to landfill could lead to a bans on sending mattresses to landfill in the long term. Therefore alternative processing routes will be required.	Limited capacity and viable locations for mattress recyclers to high population densities in Scotland. Poor quality of mattresses supply (e.g. wet or soiled), particularly if LA who may not have direct control over quality. Cheaper alternatives viewed as acceptable by waste handlers and LAs due to cheaper costs(i.e. landfill or shredding). May require change in way LAs handle mattresses which may place additional cost and operational burden. In the longterm, changes to mattresses design and materials composition may impact on recycling operations, for example the materials extracted for recovery.

5 Conclusions: developing mattress recycling infrastructure in Scotland

The opportunity to develop mattress recycling in Scotland has been described using evidence gathered from within Scotland, the UK and wider afield. The lack of recycling capacity in Scotland provides a potential opportunity for starting up a business recycling materials from waste mattresses; however, this is probably indicative of the marginal nature of this business. Recycling mattresses could provide a way of preventing large quantities of materials from being sent to landfill. The materials used in mattresses have value when separated, and political drivers are pushing towards minimising waste sent to landfill and increasing recycling rates. These factors together provide a stimulus for this potential opportunity.

A three-year plan has been produced to outline how a potential mattress recycling operation in Scotland could be started. This plan has been developed from information gathered from recyclers, waste managers and other actors. Based on this information, the most appropriate option for developing a recycling process is one based on manual separation as this fits with the scale of waste mattress arisings. The unsophisticated nature of this process belies its effectiveness. Deconstructing mattresses is an awkward task because of variability in their construction and durability. Evidence indicates that it is difficult and generally unsuccessful to process mattresses mechanically, and recyclers often return to manual deconstruction. Investment in a specialist large scale piece of automated de-construction equipment seems non-viable due to the geographical distribution of mattress arisings in Scotland.

The major start-up costs for this operation are associated with the purchase of capital equipment. Modest funding of around £15,000 would cover the purchase of essential equipment such as a forklift truck, baler, operative equipment and ICT equipment. This would ensure the business started with minimal loans. Larger funding, or a loan, could be provided to support the purchase of a steel compactor early on. This would increase the value of the steel fraction to end markets, increasing turnover. The cost of this is estimated at £150,000. The business could be supported on a continuing basis - for instance, full or part payment of rental costs for the first two years while the business was becoming established; this is a strategy used in some economic development zones to encourage new businesses to develop. For example, the Scottish Government's recently published Economic Strategy committed to establishing four Enterprise Areas with fourteen sites across Scotland to support dynamic industries.[34]

Income is generated through a combination of gate fees for mattresses and sales of materials to end markets. The majority of income arises from the gate fee. From information gathered during this study it was found that a £5 charge per mattress is reasonable based on other mattress recycling operations. However, in the circumstances outlined above a higher gate fee of around £6.25 is required to make the business viable. Ability to increase this charge beyond £5 seems unlikely without outside intervention. Materials are assumed to contribute a lower value at £1.15 per mattress based on the end markets identified. The business case is reliant on these values, which assume that LAs are willing to pay additional costs for mattress recycling over landfill, and that the identified end markets will be available. However, using these figures the business becomes economically viable, reaching breakeven in year 2 and profit in year 3. Cumulative net cash flow is still negative at the end of year 3, though is likely to be positive in year 4 if similar performance is seen.

Several barriers to the development of mattress recycling infrastructure in Scotland were identified. Of these the most important are linked to economic factors, and in particular:

- obtaining a high enough gate fee to sustain the business and therefore make it attractive for development;
- high reliance on the gate fee for sustaining the recycling business due to the low value of materials to end markets (this is linked to poor quality of materials arising from mattresses and inadequate collection methods lowering the value further); and
- inability to reduce costs further due to tight margins.

[34] http://www.scotland.gov.uk/Topics/Economy/EconomicStrategy/Enterprise-Areas

These issues linked together mean there is little incentive for development from an economic perspective. Other barriers arise around operations, particularly around ensuring that a supply of suitable mattresses that are clean and dry can be found. Buy in for the service from LAs is critical, as the business is reliant on this for operation. On a purely cost basis landfill is cheaper than recycling at present, and evidence suggests that it will this will continue for at least 3 years despite the increase in landfill tax. Therefore other drivers such as the need for environmental performance or landfill avoidance are required if LAs are to engage in mattress recycling. This is also true for retailer take-back schemes which are exposed to similar circumstances.

Due to these factors external interventions are likely to be necessary to make mattress recycling attractive to investors and to initiate the development of commercial mattress recycling in Scotland. For example, the Scottish Government could provide incentives for businesses and support to on-going operations through direct actions. Most crucially these should provide greater certainty over the income from each mattress processed, removing some of the risk associated with the income stream. Options include:

- Subsidies and grants for recyclers, potentially based on the number of mattresses processed or on materials sold on to end markets.
- Grants or loans could be provided to purchase capital equipment at start-up, or later on in the business cycle to make it more efficient through one-off pieces of equipment. This would remove the need for up-front finance and lower any debt burden arising before cash in-flow from gate fees and materials has started.
- Interventions could also aim to support the business by reducing on-going costs; for example, through subsidies for business rates or leasing. These are the largest costs associated with the business, so would provide steady support for the business.
- Supporting innovation in technologies and techniques which enable lower cost mattress recycling.

Actions such as these could be funded through the introduction of an advanced disposal fee, which would feedback money into such schemes. This fee would be included in the sale of a mattress, increasing its price by a small amount but leading to the reduction of waste sent to landfill. A similar approach has been successfully adopted for tyres.

Other interventions could be indirect or occur through policy changes:

- End market development. At present the end market options for materials reclaimed from mattresses are limited. This is mainly a result of a lack of options due to the poor quality of materials, perceptions over their cleanliness and saturation of the markets. Developing end markets for these materials, for instance for the reprocessing into new mattresses, would provide greater options and increase the sale value of the materials. In turn this would reduce the reliance on gate fees, and potentially lead to higher value uses of recycled materials.

- Stipulation of a gate fee for waste mattresses by the Scottish Government. This could be set at a price which ensures that recycling is viable and could vary dependent on the disposal option taken. However, development of end markets may be required to ensure recycling actually occurs.

- Developing existing retailer take-back services which more closely fit with recycling operations and have wider coverage. This could provide a reliable supply of waste mattresses, and ensure that the condition of mattresses arriving at recyclers is good enough to enable recycling. In addition a greater proportion of the take-back charge could be passed on. This could be facilitated through an extended producer responsibility approach.

- A better understanding of collection economics and reverse logistics for mattresses could be developed to identify whether interventions could be made during this stage. This would allow alternative methods of collection to be investigated which are more aligned to the needs of mattress recycling. Potentially such schemes could involve other bulky waste streams to derive mutual benefit from this process.

- Improvements in design. At present the design of mattresses prevents easy deconstruction and separation of materials. Encouraging design principles which align to end of life processing could be encouraged through mechanisms such as standards or ecolabel schemes. However, this would likely take a long time to have an impact as mattresses have a lifetime of several years.

- Banning mattresses from landfill sites would ensure alternative disposal options are found. However this may not result in a greater number of mattresses being recycled, as cheaper alternatives such as may still be viable. Other consequences may also arise such as increased illegal dumping. Therefore careful consideration and implementation is required.

As has been discussed, mattress recycling is marginal economically based on the plan described above, and margins are tight. The critical risks for this business are identified as:

'Buy in' from local authorities. A suitable and regular supply of mattresses is required for this business to function. Local authorities are highlighted as the best source. However, there may be difficulties engaging them if other contracts are in place, particularly if they offer a cheaper service. The mattresses recycled must also be delivered dry and unsoiled for the materials to be saleable, therefore changes to the way LAs handle mattresses may be required.

Maintaining the gate fee. This business model is particularly sensitive to the gate fee of the mattresses, as this accounts for the majority of the income. At present it is assumed that £6.25 per mattress is possibly, justified by the recognised benefits of recycling. However, any deviation from this value will impact greatly on the business. Again, without external intervention this is reliant on LAs.

Both these factors have the potential to strongly influence the business; however, mitigation is possible through negotiation of long term contracts, with agreements to pay a certain gate fee.

Appendix I – Supporting information for the business case

Supply[35]

UK and Scottish mattress sales 2010

Mattress type	Total UK (Units)	Total weight UK (Tonnes)	Total Scotland (Units)	Total weight Scotland (Units)	Average weight (kg)
Spring	4,447,095	110,804	371,783	9,263	24.4
PUR Foam	1,922,149	25,257	160,694	2,112	13.1
Latex	97,512	2,209	8,152	185	22.7
TOTALS	**6,466,750**	**138,270**	**540,629**	**11,560**	**21.4**

Non-domestic mattress markets in Scotland with estimated sales

Market	Estimated units	Weight	Type	Market share, based on units(%)
Care homes	46,000	970 tonnes	Mixed	8.50%
Hospitality	45,000	948 tonnes	Mixed	8.30%
Prisons	3,900	42 tonnes	PUR foam	0.70%
Armed forces	3,300	67 tonnes	Mixed	0.60%
NHS	3,100	31 tonnes	PUR foam	0.60%

[35] Data from Appendix II

Materials demand[36]

Composition of mattresses sold in the UK, 2010

	Latex			PUR foam		
Material	**Composition (%)**	**22.7 kg mattress**	**Total weight for latex (Tonnes)**	**Composition (%)**	**13.1kg mattress**	**Total weight for PUR foam (Tonnes)**
Steel	0%	-	-	0%	-	-
PUR foam	0%	-	-	83%	10.9	20,938
Latex foam	90%	20.4	1,988	0%	-	-
Cotton, woven	6%	1.36	133	10%	1.35	2,601
Cotton, non-woven	2%	0.45	44.2	3%	0.45	859
Wool	2%	0.45	44.2	3%	0.45	859
Polyester, non-woven	0%	-	-	0%	-	-
Fibres	0%	-	-	0%	-	-
Felt	0%	-	-	0%	-	-
Total		**22.7**	**2,209**		**13.1**	**25,257**

	Sprung			All	
Material	**Percentage**	**24.9kg mattress**	**Total weight for sprung (Tonnes)**	**Total weight of all for mattresses**	**Average mattress composition**
Steel	36%	9.07	40,333	40,333	6.2
PUR foam	12%	2.94	13,075	34,013	5.3
Latex foam	2%	0.45	1,994	3,983	0.6
Cotton, woven	6%	1.37	6,094	8,828	1.4
Cotton, non-woven	18%	4.54	20,166	21,069	3.3
Wool	4%	0.90	3,989	4,892	0.8
Polyester, non-woven	5%	1.12	4,986	4,986	0.8
Fibre	9%	2.27	10,083	10,083	1.6
Felt	9%	2.27	10,083	10,083	1.6
Total		**24.9**	**110,804**	**138,270**	**21.4**

[36] Data from Appendix II

Alternative mechanical equipment for mattress processing[37]

	Equipment	Manufacturer	Function	Indicative price	Commercially available
1	Automated mattress processor	Westwoude (NL)	Fully automated system - sorts mattresses and strips and sorts materials. Capacity of 190,000 mattresses per year (1 shift)	£1,600,000	Yes
2	Mattress 'filleter'	In-house	Separates ticking (outer shell) from rest of mattress allowing easier disassembly	Unknown	No
3	Mattress shredder	Enerpat (UK)	Shreds full mattresses, no materials separation. Ferrous metals can be separated using another piece of equipment.	£80,000, or £305 PW over 5 years	Yes
4	Mattress baler (multiple)	Enerpat (UK)	Compresses several mattress to reduce space, and improve processing speed using standard shredding equipment	£12,000	Yes
5	Mattress baler (single)	Enerpat (UK)	Compresses mattress (singly) reducing volume by up to 80%. Allows processing on shredding line.	£20,000	Yes
6	General waste shredding line (requires baler)	Enerpat (UK)	Shreds waste materials, and separates out ferrous materials. Requires mattress baler(single) to process mattresses	£84,000	Yes
7	Steel compactor	Various	Compacts springs, increasing the scrap value of the metal potentially by 3 times.	£150,000 (second hand)	Yes

Of these items, 1 and 2 are specifically designed to increase the rate and quality of mattress processing as part of a recycling process. However the automated mattress processor requires a large number of mattresses to be viable. Little is known about item 2, because at present it is not commercially available. Items 3, 4, 5 and 6 increase the rate at which mattresses can be processed, but the shredding reduces the value of textiles and other materials and they are only suitable for landfill cover. This equipment is aimed at waste processing contractors handling various types of waste that need to be process mattresses along with other standard waste. Item 7 is a piece of equipment that reduces the volume of steel springs, thereby increasing the value of this waste stream. Compaction can increase the value of steel from £80 to £200 per tonne, or an average increase of 74p per mattress. Therefore if financed over five years it can be estimated that this piece of equipment requires a capacity of around 50,000 mattresses per year to be economical based on increased steel prices.

[37] Data from appendix III

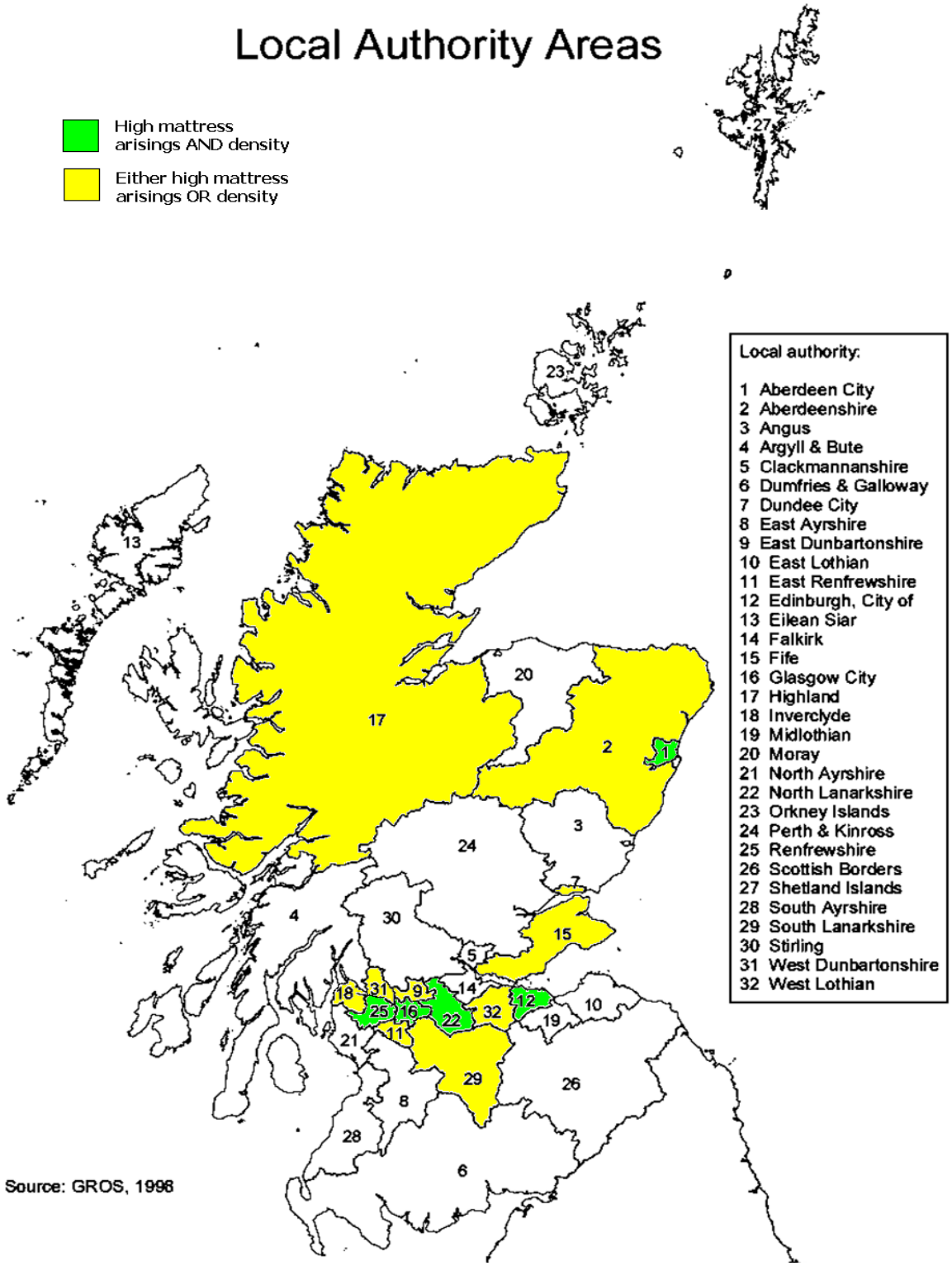
Estimated mattress arisings for each LA in Scotland[38]

Those LAs that have the largest number of mattresses disposed of, and most disposed of per square mile, are highlighted.

Local authority	Area (sq miles)	Estimated disposal through LAs	Tonnage in waste	Arisings per square mile	Total highlighted
Aberdeen City	70	15,052	322	215	2
Aberdeenshire	2,439	18,849	403	8	1
Angus	843	8,169	175	10	0
Argyll & Bute	2,712	7,479	160	3	0
Clackmannanshire	61	3,394	73	56	0
Dumfries & Galloway	2,489	10,713	229	4	0
Dundee City	21	10,107	216	481	1
East Ayrshire	492	8,728	187	18	0
East Dunbartonshire	68	7,260	155	107	1
East Lothian	257	6,934	148	27	0
East Renfrewshire	65	6,073	130	93	1
Edinburgh, City of	100	33,311	713	333	2
Eilean Siar	1,185	2,284	49	2	0
Falkirk	113	10,052	215	89	0
Fife	517	24,756	530	48	1
Glasgow City	68	39,625	848	583	2
Highland	10,085	17,498	374	2	1
Inverclyde	64	5,807	124	91	1
Midlothian	135	5,700	122	42	0
Moray	864	6,999	150	8	0
North Ayrshire	343	10,225	219	30	0
North Lanarkshire	184	22,314	478	121	2
Orkney Islands	396	1,542	33	4	0
Perth & Kinross	2,083	10,583	226	5	0
Renfrewshire	102	11,979	256	117	2
Scottish Borders	1,825	8,303	178	5	0
Shetland Islands	568	1,436	31	3	0
South Ayrshire	475	8,422	180	18	0
South Lanarkshire	686	21,942	470	32	1
Stirling	866	6,091	130	7	0
West Dunbartonshire	68	6,085	130	89	1
West Lothian	165	11,968	256	73	1
Total		**369,680**	**7,911**		

[38] Data from appendix II

Map of local authorities, showing areas of high mattress arisings and high density of arisings.



Materials value scenarios[39]

Indicative value of separated materials to end markets. These assume local markets are available, therefore if long distance transport is required actual values may be lower due to costs associated with collection.

Material	Value per tonne	Value per kg	Value per average mattress
Steel			
Normal (uncompressed)	£80	£0.08	£0.50
Compressed	£200	£0.20	£1.24
PUR foam			
Carpet underlay	£100	£0.10	£0.53
Energy from waste/RDF	£36	£0.04	£0.19
Landfill cover	£0	£0	£0
Latex foam			
Energy from waste	£36	£0.04	£0.02
Landfill cover	£0	£0	£0
Mixed textiles			
Baled (low value)	£50	£0.05	£0.47
Baled (high value)	£88	£0.09	£0.82
Energy from waste/RDF	£36	£0.04	£0.33
Landfill Cover	£0	£0	£0
Landfill 2010 (all)	-£82	-£0.08	-£1.75

[39] Data from Appendix III

Scenarios for materials fates

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Steel	Normal	Normal	Normal	Normal	Normal	Compressed
PUR	Carpet underlay	Carpet underlay	EfW/RDF	EfW/RDF	EfW/RDF	Carpet underlay
Textiles	Baled (low value)	Baled (high value)	Baled (low value)	Baled (high value)	EfW/RDF	Baled (high value)
Latex	Landfill	Landfill	EfW/RDF	EfW/RDF	EfW/RDF	EfW/RDF
Fibres	Landfill	Landfill	EfW/RDF	EfW/RDF	EfW/RDF	EfW/RDF

Income from mattresses (including gate fee), based on materials fate scenarios above

	Weight per mattress (kg)	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Steel	6.20	£0.50	£0.50	£0.50	£1.24	£0.50	£1.24
PUR foam	5.30	£0.53	£0.53	£0.19	£0.19	£0.19	£0.53
Textiles	7.70	£0.47	£0.82	£0.47	£ 0.82	£0.33	£0.82
Latex	0.60	-£0.04	-£0.04	£0.02	£0.02	£0.02	£0.02
Natural Fibres	1.60	-£0.13	-£0.13	£0.06	£0.06	£0.06	£0.06
Total materials		**£1.45**	**£1.81**	**£1.17**	**£2.27**	**£1.04**	**£2.61**
Gate fee		**£6.25**	**£6.25**	**£6.25**	**£6.25**	**£6.25**	**£6.25**
Total per mattress		**£7.48**	**£7.77**	**£7.40**	**£8.44**	**£7.29**	**£8.78**

Appendix II – Arisings and disposal routes of mattresses in Scotland and the UK

1 Introduction

1.1 Background

Both the Zero Waste Plan (2010) and the Scottish Government's Revised Economic Strategy (2011) put waste textiles high on the agenda both environmentally and economically. Textiles are a valuable resource stream for both materials and products; collection, processing, re-use and remanufacturing of textiles could generate inward investment and jobs in Scotland while conserving resources for future trade and manufacture. Waste mattresses are a major source of waste textiles.

1.2 Scope and definition

For the purpose of this report and the data generated it is important to define what constitutes a mattress. According to the current Ecolabel Criteria for mattresses[40] the definition of a bed mattress is considered to be:

A. A product that provides a surface to sleep or rest upon for indoor use. The product consists of a cloth cover that is filled with materials, and that can be placed on an existing supporting bed structure.
B. Materials filling the bed mattresses may include latex form, polyurethane foam and springs.
C. Wooden bed bases that support the bed mattresses.

The product includes spring mattresses, which are defined as an upholstered bed base consisting of springs, topped with fillings, as well as mattresses fitted with removable and/or washable covers, but not including inflatable mattresses and water mattresses, as well as mattresses classified under EC Directive 93/42/EEC (the Medical Devices Directive).[41,42]

For consumption purposes, PRODCOM (Products of the European Community) lists manufactured product sales by EU Member State, and lists trade import and export data, both within and outside the EU. For the purposes of this report, PRODCOM codes within Division 31 – Manufacture of furniture are included, specifically:

- 31031230 - Mattresses of cellular rubber INCLUDING: - with a metal frame
- 31031250 - Mattresses of cellular plastics INCLUDING: - with a metal frame
- 31031270 - Mattresses with spring interiors EXCLUDING: - of cellular rubber or plastics
- 31031290 - Mattresses EXCLUDING: - with spring interiors - of cellular rubber or plastics (referred to as 'other' mattresses)

Excluded for the purposes of this report is code 31031100 - Mattress supports.

This appendix describes the arisings and disposal routes for mattresses within Scotland and the UK.

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[40] Commission Decision 9th July 2009 (2009/598/EC)
[41] 'Medical device' mattresses include those with a specific design to provide medical or therapeutic function, such as those with adjustable air pockets, heating capabilities or similar.
[42] Europa Council Directive 93/42/EEC, Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1993L0042:20071011:en:PDF

2 Consumption

2.1 Sales data by type of mattress

PRODCOM data gives robust detail of recorded sales and trade data for the UK, based on Standard Industrial Classification (SIC) codes for products. This is used as an initial source of consumption, giving official data for number of units produced in the UK, alongside trade data of import and export in tonnages.

The number of mattresses consumed new in the UK in 2010 was 7.9 million units[43], equating to approximately 169,000 tonnes (Table 2.2), the majority of which were produced within the country (Table 2.1).

Table 2.1 PRODCOM based production of mattresses in the UK, 2010

Mattress type	Number of units in category	UK Single mass (kg)	Percentage sales of size	Number of units	Total Weight Prodcom Sales (Single) tonnes
Cellular Rubber single[44]	89,650	17.38	40%	35860	623
Cellular Rubber double	89,650	26.17	60%	53790	1,408
Cellular Plastic single[45]	1,486,727	10.08	40%	594690.8	5,994
Cellular Plastic double	1,486,727	15.18	60%	892036.2	13,541
Spring single	4,228,437	19.12	40%	1691375	32,339
Spring double	4,228,437	28.78	60%	2537062	73,017
Others single	881,286	15.53	40%	352514.4	5,475
Others double	881,286	23.38	60%	528771.6	12,363
TOTALS	6,686,100			6,686,100	144,759

Source: Calculated from ONS PRODCOM, 2010 estimates; using industry conversion factors.

[43] Calculated from ONS PRODCOM, 2010 estimates; using industry conversion factors
[44] Cellular rubber is commonly referred to as Latex
45 Cellular plastic is commonly referred to as PUR foam

Table 2.2 PRODCOM based consumption of mattresses in the UK, 2010

Mattress type	Number of units in category	UK Single mass (kg)	Percentage sales of size	Number of units	Total Weight Prodcom Sales (Single) tonnes
Cellular Rubber single	97,523	17.38	40%	39,009	678
Cellular Rubber double		26.17	60%	58,514	1,531
Cellular Plastic single	1,922,118	10.08	40%	768,847	7,750
Cellular Plastic double		15.18	60%	1,153,271	17,507
Spring single	4,447,106	19.12	40%	1,778,842	34,011
Spring double		28.78	60%	2,668,264	76,793
Others single	1,504,562	15.53	40%	601,825	9,346
Others double		23.38	60%	902,737	21,106
TOTALS	7,971,309			7,971,309	168,722

Source: calculated from ONS PRODCOM, 2010 estimates; using industry conversion factors

Spring based mattresses account for both the largest volume of mattresses produced and consumed, accounting for 66% of UK consumption by weight. Cellular rubber mattresses are the smallest market share, accounting for only 1.3%.

2.2 Material composition

In general a mattress is a complex construction consisting of core, shell and tick.

Core: The core provides for the support of the mattress. The main materials which are being used are steel springs, polyether foam and latex foam. Horsehair and coconut fibre are also used as core materials, e.g. for babies' mattresses.

Shell: The shell or padding consists of a layer around the core. The purpose of this shell is to equalize the pressure on the human body. All mattresses with a spring interior and some of the mattresses with other core materials contain a shell. Often mattress shells are composite structures. The materials typically used are:

- polyether foam (polyurethane or PU foam)
- latex foam
- horse hair and camel hair (both sometimes rubberized)
- coconut fibres (sometimes rubberized)
- polyester (pet or poly-ethylene-terephthalate)
- cotton
- wool
- linen
- felt
- jute
- sisal.

The production method of the shell depends of course on the materials used. In general the materials used are glued and/or sewed to each other and on the core. Staples are also used to fix materials together (creating a barrier at end-of-life).

Tick: The outer cover of the mattress is called the tick or ticking. It provides a comfortable top layer. The main woven materials used for the tick of mattresses are:

- cotton
- polyester (pet or poly-ethylene-terephthalate)
- silk
- polypropylene
- nylon (polyamide)
- wool
- viscose.

The tick can be fixed to the mattress by means of stitching or by tapes running through the mattress (tufting). Sometimes the tick is not fixed, but can be removed from the mattress by the customer.

The approximate material composition in terms of kg/m^2 of spring, latex and polyether mattresses has been provided by Deliege and Nijdam[46]. Using these values the typical percentage and weight of each component can be estimated for the three types of mattress (Table 2.3).

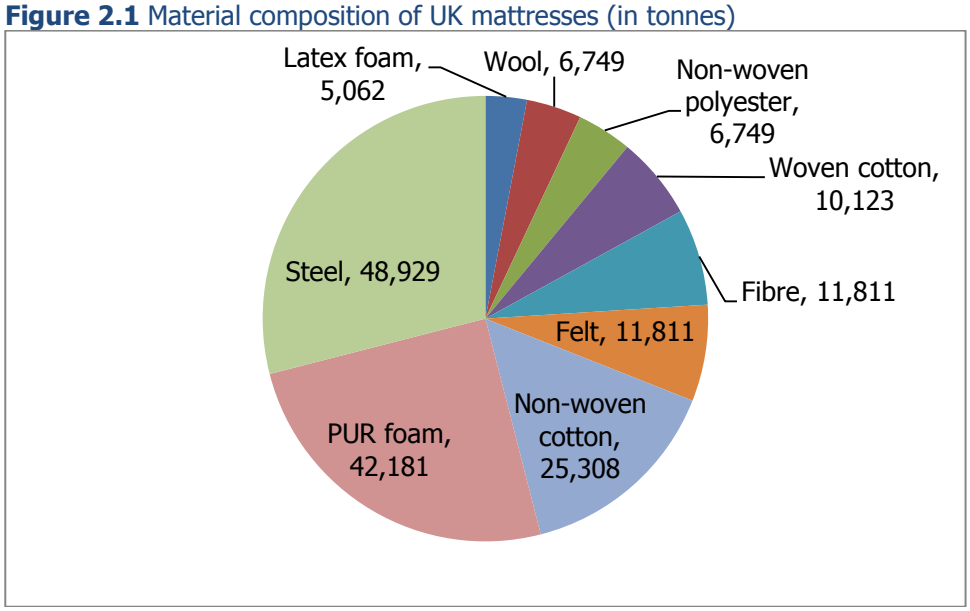
Table 2.3 Mattress composition by type

Material component	Percentage composition		
	Spring	Cellular plastic	Cellular rubber
Steel	36.4%		
PUR foam	11.8%	82.8%	
Latex foam	1.8%		90.0%
Cotton, woven	5.5%	10.3%	6.0%
Cotton, non-wov	18.2%	3.4%	2.0%
Wool	3.6%	3.4%	2.0%
Polyester, non-woven	4.5%		
Fibres (e.g. coconut)	9.1%		
Felt	9.1%		
Total	100%	100	100

Based upon the individual compositions, and applying these to the tonnages sold in the UK, the overall mattress composition for the country can be considered as equating to that given in Figure 2.1.

[46] LCA and Criteria Proposals Final Report for the EC - Report No. R3535924.W05/EJD: E.J.M. Deliege and D.S.C. Nijdam

Figure 2.1 Material composition of UK mattresses (in tonnes)



2.3 Mattress construction

The construction of mattresses varies – specifically within sprung mattresses, and this may have an effect on deconstruction should the mattress be recycled. Several types of mattress exist within the categories of mattress, the main ones listed below:

- individually wrapped spring coils (pocket-springs)
- individually placed spring-coils (Bonell springs)
- LFK (LeichtFederKern) springs (cylindrical springs)
- springs embedded in rubberized foam
- a core of endless-wire springs
- other.

3 Sectoral breakdown

An EU study calculated that household mattresses accounted for approximately 95% of the total mattresses in the EU[47] with the remainder generated by hotels (3%) hospitals (1%), and military establishments, prisons and trains (1%). The National Bed Federation more recently (2012) places the commercial and public sector consumption of mattresses higher, with only 80% of mattress consumption from household use[48].

3.1 Domestic

According to Nat Bed Fed 80% of consumption is domestic household use, equating to 134,980 tonnes of mattresses consumed in the UK for domestic household purposes, with 11,200 tonnes in Scotland.

[47] Deliege and Nijdam, 1998. European ECOlabel Bed Mattresses, LCA and criteria proposals final report for the EC Report number: R3535924.W05/EJD.
[48] Personal communication, National Bed Federation, 2012

3.2 Hospitals/healthcare services

Generally, hospital mattress producers are often specialists in health products and mattresses are supplied alongside other medical equipment. There are, however, examples of domestic suppliers producing mattresses for hospital use. For example, Elite, a Swiss bedding manufacturer, produces two types of medical mattresses both with a foam core, and a PVC mattress cover. All are sanitised and conform to European fire safety standards.[49]

Hospital mattresses appear to be predominantly made of a polyether foam or latex foam core with a PVC cover as a protective layer. Foam mattresses for domestic use are often more expensive than inner sprung mattresses, but for hospital use they are deemed to be more comfortable, and also conform to different laying and sitting positions by bending with adjustable bed frames. There are a variety of different standard mattresses in use throughout Europe and a set of grades within these, dependant on the risk level of the patient. Due to constant use, it is estimated that the life of a UK Standard Hospital mattress is only nine to eighteen months, a considerably higher turnover rate than mattresses for other uses.[50]

According to the British Healthcare Trades Association (BHTA)[51], on average between 15% and 20% of foam mattresses are replaced each year indicating a market consumption of 40,000 foam mattresses per annum which if classified as UK Singles would equate to approximately 403 tonnes. The data provided by the various NHS supply organisations for all the Nations would suggest that if mattress purchases are mainly linked to replacement of old mattresses, then for 2011, for example, the UK in total replaced just below 10,000 units rather than 40,000 as suggested by the BHTA. This may be due to the inclusion of mattresses excluded from the remit of this report – for example, those listed as 'Medical devices' under Council Directive 93/42/EEC which have specialist therapeutic functions.

In comparing the overall 2010 mattress supply to the UK of 169,000 tonnes, the hospital sector would account for 0.1% of sales (static mattresses only) which is much lower than generally quoted in the literature of approximately 1%. This may be due to inclusion of other aspects of beds not considered 'static'.

Previous reports have determined mattresses discarded based on number of beds and lifespan of a mattress. This gives a significantly higher figure, of 137,000 units[52], equating to 1,480 tonnes (based on a single cellular plastic mattress mass of 10.80 kg). For the purposes of this report, the discard tonnage is used rather than procurement tonnage.

Mattresses disposed of by the NHS do not have to be incinerated unless they are contaminated with bodily fluid, though the number of mattresses incinerated by the organisation was not determined.

3.2.1 Scottish NHS mattress supply

Data on mattress purchases for Scotland was provided by the NHS National Services Scotland, Figure 3.1.[53] In 2010, 3,098 mattresses were procured by the Scottish NHS, equating to 31 tonnes.

Of the thirteen NHS Trusts spoken to, only two Trusts were not sending mattresses to landfill, both of which were sending for heat treatment. All the Trusts were sending contaminated or clinical waste (which includes soiled mattresses) to some form of incineration, but typically, clean mattresses were being disposed of to landfill with only a small proportion sent for other treatment.

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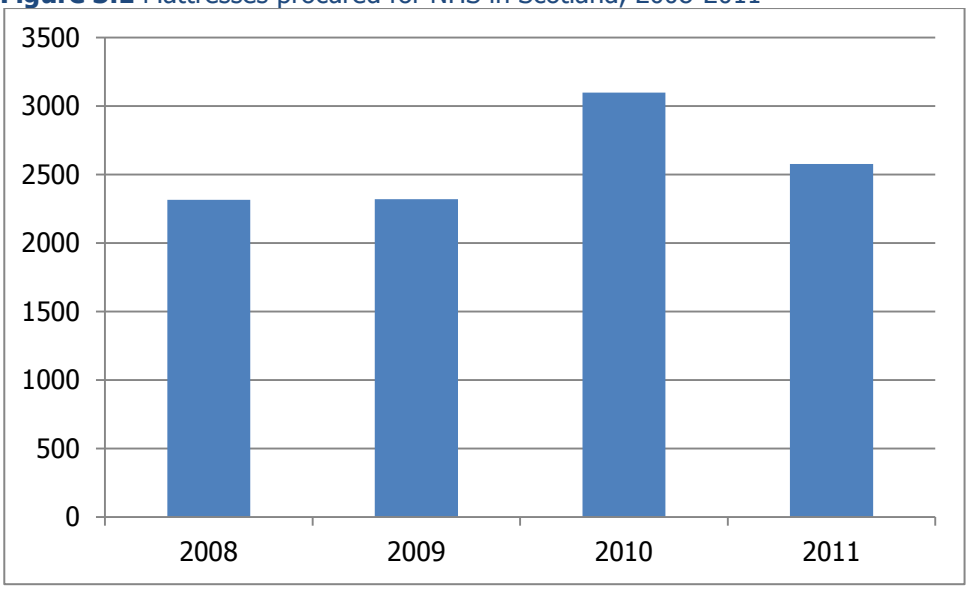
[49] Elite Beds, 2011 Available at: http://www.elitebeds.ch/en/hopitaux/viscopedic.html
[50] Available at: http://www.judy-waterlow.co.uk/pressure_ulcer_preventative_aids.htm
[51] http://www.bhta.net/
[52] Oakdene Hollins (2011) Mattress Ecolabel and Green Public Procurement Criteria: Task 3 – Market Analysis
[53] www.nhsscotlandprocurement.scot.nhs.uk

Figure 3.1 Mattresses procured for NHS in Scotland, 2008-2011



3.3 Care homes

Mattresses for nursing care homes can vary by type, as with hospital mattresses. The use and required functionality of the mattresses is also similar to that of a hospital. As no dataset was found to hold the number of mattresses consumed by care homes, data for available nursing care beds was used. It was assumed that one bed required one mattress. Data should be used with caution as a proportion of available beds may have used air mattresses which fall outside the scope of this report. In 2008, the number of available care beds was 527,000. The lifespan of a nursing care mattress is considered to be similar to that of hospital mattresses, which is 18 months[54]. The total number of mattresses purchased for nursing and residential care for the UK is estimated to be around 351,000 units in 2008, equating to 3,538 tonnes.

3.4 Prisons

As with hospitals, prisons show a tendency to use foam mattresses for reasons of functionality. These are purchased in large quantities, and have a relatively short life span. In the UK for instance 53,000 foam mattresses and 48,000 pillows are purchase by HM Prison Service on an annual basis. In total, 40,000 of these items are disposed of yearly due to soiling, misuse or wear and tear.[55]

These mattresses differ from domestic mattresses in a variety of ways and as such, it is often the case that suppliers are those who provide other products to prisons. As with hospital mattresses, these are predominantly made with a foam core and provided with protective PVC layer. High on the list of regulating factors for prison mattress production is flammability. Mattresses must conform to strict fire regulation standards.

[54] Oakdene Hollins (2011) Mattress Ecolabel and Green Public Procurement Criteria: Task 3 – Market Analysis
[55] FCP Demonstration Project: HM Prison Service Zero Waste Prison Mattress System

The following table shows the quantity of mattresses purchased for use by prisoners from 2008-2010 in the UK. It should be noted that these figures do not include private prisons, as they source items independently.[56]

Table 3.1 Mattresses procured by UK prisons, 2008-2010

Description	2008		2009		2010	
	Quantity (units)	Value (£)	Quantity (units)	Value (£)	Quantity (units)	Value (£)
Mattress, F/R Foam, STD 1.9m long	41,357	1,794,067	39,074	1,695,030	38,277	1,660,456
Mattress F/R Foam, 7 feet, 2.2m long	799	43,026	952	51,265	550	29,618
Mattress Hospital, F/R Foam	180	10,055	234	13,071	153	8,547
Mattress Narrow, F/R Foam 1.9m long	3,395	156,815	4,190	193,536	5,955	275,061
Sub-total	45,731	2,003,963	44,450	1,952,902	44,935	1,973,682

Source: http://www.publications.parliament.uk/pa/cm201011/cmhansrd/cm110301/text/110301w0004.htm#1103022002766

UK prison population was 93,000 in 2008 and in the same year nearly 46,000 mattresses were purchased. This equates to mattresses being purchased for 49% of the prison population on an annual basis.

In 2010, 44,935 mattresses were purchased, which equates to 485 tonnes of mattresses. Based on a like for like exchange this can be considered equivalent to the mattresses disposed of in the same period.

3.5 Army accommodation

To calculate the number of mattresses purchased for army accommodation, army personnel data was used. However unlike other sectors, it cannot be assumed that one person equals one mattress, as army accommodation varies greatly.

Within the UK, army personnel either live in private accommodation, single family accommodation housing (SFA) or make use of single living accommodation (SLA) individual bed spaces. Private accommodation can be excluded from the data as furniture, including mattresses, would not be purchased publically. Similarly, SFA housing is not often furnished and so is excluded from the data. Assuming one mattress per SLA bed space, the number of SLA beds can therefore be used as an estimate of the number of mattresses in use in the UK. The number of SLA beds in use in 2010 was 131,104, with 46,000 provided in 2010[57], though 6,000 of these were for overseas personnel. A total of 40,000 mattresses are considered to have been provided to the UK, which, based on average sprung mattress mass for single mattress of 19.12 kg, gives 765 tonnes of mattresses. Based upon the assumption that mattresses disposed of equate to roughly the number procured, this can be considered the disposal figure also.

3.6 Commercial (hospitality)

The largest commercial mattress users are hospitality services, such as hotels, hostels and bed and breakfast businesses. Based upon the National Bed Federation's estimation that 20% of mattresses are used for all of the previous sections, bar domestic, 1.58 million mattresses are believed to be utilised by these non-domestic sectors. The

[56] UK Parliament website, Prisons: furniture. Available at: http://www.publications.parliament.uk/pa/cm201011/cmhansrd/cm110301/text/110301w0004.htm#1103022002766
[57] http://www.publications.parliament.uk/pa/cm201011/cmhansrd/cm110304/text/110304w0002.htm

combined total of prisons, hospital, care home and army mattresses is 572,000 mattresses, the remaining 1.01 million are believed to be utilised by the hospitality sector in the UK.

The 'accommodation and food services' sector in Scotland includes 15,535 enterprises[58]. According to the British Hospitality Association (BHA)[59], the total number of 'structured service industry number of rooms' is 45,000 – this includes all of the following accommodation styles:

- hotels
- hostels
- caravan parks
- youth hostels
- bed and breakfast.

It can realistically be estimated that number of mattresses loosely equates to 1-2 times the number of rooms (this is a conservative estimation due to family rooms and youth hostels etc), equating to 45,000-90,000 mattresses, or an average of 67,500 in the commercial sector in Scotland. The average mattress life for a hotel mattress is 7 years[60], though many hotels keep them for far less time. One hotel chain interviewed suggested mattress replacement took place every four years[61]. Youth hostels, caravan parks and other, lower cost accommodation is considered to use lower premium mattresses, and replacement is therefore more frequently required. An estimate of one third of mattresses in commercial use being replaced a year is given, equating to 15,000-30,000 per year (this is roughly 1.5-3% of total hospitality disposal for the UK).

3.7 Summary of consumption

The total of all mattresses consumed per sector is given in Table 3.2.

Table 3.2 Mattress consumption by sector in the UK, 2010

Sector	Mattress consumption in UK (number of units 000's)	Mattress consumption in UK (tonnes)
Domestic	6,320	134,980
Commercial	1,010	21,210
Hospitals	137	1,480
Care homes	351	3,538
Prisons	44	485
Army accommodation	40	765
Other		6,264
Total	7,902	168,722

'Other' mattresses consumed is believed to account for the additional 6,300 tonnes of mattresses included within PRODCOM consumption data. This is a vague sales category, and is believed to include mattresses unaccounted for within the specific listings above – for example, this may include camping mattresses or any other non-classified mattresses.

Mattress consumption in the UK is dominated by domestic use, and these are also the most variable mattress types, with spring mattresses preferred by householders. Hospitals, care homes and prisons typically use foam mattresses, for

[58] ONS (2011) Business population estimates for the UK and regions, 2010
[59] Personal communication, 2012
[60] Simmons (2012) Sustainability. Available at http://www.simmonshospitality.com/sustainability.html
[61] Personal communication, confidential - hotel chain in UK, 2012

health and safety and functionality, giving a greater proportion by number, but smaller proportion by weight of total mattress share.

4 Waste arisings

4.1 National and regional waste arisings

Mattresses are not generally detailed by local authorities, in volume to landfill. Waste compositional analyses vary as to whether they are included as a standalone item, or amalgamated with 'miscellaneous combustibles' or similar. Previous reports vary in estimations of waste arisings, estimating a range of 130-180,000 tonnes per year[6263].

The number of mattresses discarded can be considered to be the same as that purchased, based on the caveat that for each mattress purchased, one is disposed of. New build and population growth means that consumption will be higher than discard, but factoring in disposal for other reasons (for example, a couple moving in together, and house demolition) the number is considered representative, though more detailed waste analyses will help identify more accurate arisings.

4.1.1 UK

If presuming that mattresses are replaced at the same time as purchase, then 169,000 tonnes of mattresses are entering the waste stream per year, of which 144,000 tonnes are believed to be disposed of to landfill.

4.1.2 Scotland

Mattress waste data was not reported in Waste Digest by any Scottish local authorities, and a sample of interviews (10 of 33 authorities were spoken to) highlighted lack of information on how many mattresses were discarded by households. Those local authorities who offered pick up did not collect waste data, and did not have any awareness of historic mattress waste arisings. A detailed compositional study[64] of municipal solid waste was conducted for 2008/09. Mattresses were found to be 0.01% of residual household waste, and 4.07% of HWRC waste, equating to 153t and 9,970t respectively, giving just over 10,100t in that year.

More recent breakdown of HWRC waste arisings in Scotland was not available, and therefore estimations for 2010 are based upon population and number of dwellings. In mid-2010, there were 2.36 million households in Scotland – around 162,000 (7.4%) more than in 2001. The total consumption of mattresses in Scotland is estimated to be 14,000 tonnes, based on a per capita allocation for the UK; this is considered to be the same volume being disposed of, based on the caveat of a mattress discarded for each mattress purchased.

A study carried out by WRAP[65] in 2012 found that mattress arisings collected through bulky collections and HWRCs put arisings at 166,000 t pa across the UK. Applying Barnett this would equate to 16,600 t pa arisings in Scotland.

4.1.3 Regional distribution

Regional recordings of mattresses to landfill are not recorded, and therefore accurate understanding of waste arisings is difficult; the following section is suggested as guidance only. Scottish dwellings are recorded by number of rooms[66],

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[62] WRc Plc Report, Summary, 'UK Feasibility Study – Opportunities for Resource Efficiency with Respect to End-of-life Mattresses'
[63] Centre for Remanufacturing and Reuse (2008) Mattresses
[64] ZWS (2010) The composition of municipal solid waste in Scotland
[65] http://www.wrap.org.uk/content/huge-re-use-potential-bulky-waste-revealed-new-wrap-report
[66] Estimates of households and dwellings in Scotland, 2010, National Records of Scotland, Published 19th May 2011

and this can be used as a basis of estimation for number of mattresses. Number of mattresses estimated per dwelling are given in Table 4.1.

Table 4.1 Estimated number of mattresses per dwelling, based on number of rooms

Number of rooms per dwelling	Estimated number of mattresses
1-3	1
4-6	2
7+	3
Unknown	1.5

The total stock of mattresses for the area was determined by using an estimated number of rooms multiplied by the number of dwellings, with each given number of rooms in each local authority area,.

Only four local authorities reported mattress recycling in Scotland in 2010. Each of these were interviewed and each collected all mattresses sent for bulky waste collection, or deposited at a HWRC site, with 100% capture of those mattresses which would otherwise have been deposited at local authority sites. Therefore, it can be considered that the recycling rate is equivalent to the waste arisings of mattresses which would otherwise have been handled. The average stock waste arising rate was 9.1% (ranging from 6% to 15.7%).

Applying 9.1% to the total stock of each local authority area gives a total of 7,800 tonnes of mattresses, distributed across the regions as shown in Table 4.2.

Table 4.2 Mattress arisings in each local authority area, 2010

Local Authority	Number of mattresses	Estimated mattress disposal	
		Number of units	Tonnage
Aberdeen City	165,342	15,052	316
Aberdeenshire	207,053	18,849	396
Angus	89,740	8,169	172
Argyll & Bute	82,155	7,479	157
Clackmannanshire	37,280	3,394	71
Dumfries & Galloway[2]	117,684	10,713	225
Dundee City	111,023	10,107	212
East Ayrshire	95,877	8,728	183
East Dunbartonshire	79,752	7,260	152
East Lothian	76,170	6,934	146
East Renfrewshire	66,713	6,073	128
Edinburgh, City of	365,917	33,311	700
Eilean Siar	25,094	2,284	48
Falkirk	110,421	10,052	211
Fife	271,943	24,756	520
Glasgow City	435,278	39,625	832
Highland	192,217	17,498	367
Inverclyde	63,791	5,807	122
Midlothian	62,616	5,700	120
Moray	76,879	6,999	147
North Ayrshire	112,319	10,225	215
North Lanarkshire	245,112	22,314	469
Orkney Islands	16,937	1,542	32
Perth & Kinross	116,252	10,583	222
Renfrewshire	131,588	11,979	252
Scottish Borders	91,210	8,303	174
Shetland Islands[3]	15,772	1,436	30
South Ayrshire	92,515	8,422	177
South Lanarkshire	241,030	21,942	461
Stirling	66,914	6,091	128
West Dunbartonshire	66,845	6,085	128
West Lothian	131,465	11,968	251
Total	4,060,904	369,680	7,763

This does not take into account arisings collected by other parties, such as retailer take-back schemes, which are considered in section 4.3.2.

4.2 Material arisings

Based on the percentage breakdown of materials given in Figure 2.1, the available material from end of life mattresses in Scotland is estimated to be shown in Table 4.3.

Table 4.3 Material arisings from Scottish mattress waste stream, 2010

Material	Tonnage
Steel	4,060
PUR foam	3,500
Non-woven cotton	2,100
Fibres (e.g. coconut)	980
Felt	980
Woven cotton	840
Wool	560
Non-woven polyester	560
Latex foam	420
Total	**14,000**

As discussed in Section 2.2, steel, PU and non-woven cotton are the significant arisings available, with over 4,000 tonnes of steel alone.

4.3 Disposal routes

There are several means to dispose of mattresses if no longer wanted. The most common are listed below:

- Direct deposit to HWRC by householder.
- Bulky waste collections by local authority (these may be carried out by waste contractors or reprocessors)
- Retailer take-back – the only examples found involved the take-back of old mattresses at the point of delivery of new.
- Flytipping – this is the illegal dumping of mattresses (or other waste) at non-licenced deposit points, e.g. at the roadside.
- Direct donation – some small examples of collections by reprocessors directly to the householder were found, but these were not known to be significant.

4.3.1 Bulky waste collection and HWRC deposit

Local authorities typically offer a bulky waste collection for a small fee, ranging from nothing for the first few items, to around £25 per pick up. Of local authorities interviewed, mattresses in bulky waste are deposited at the HWRC, either for recycling, in which case they are segregated and sheltered, or for landfill.

Local authorities spoken to did not record mattress tonnages to HWRC or collected in bulky waste (typically recorded as number of units – which could include white goods, furniture or other bulky items), unless mattresses were collected. Where this was the case, collections were combined, giving a single figure. Only four local authorities reported recycling mattresses: Edinburgh, Fife, Falkirk and Stirling. Figures given in Table 4.2 are considered to be the combined HWRC and bulky waste totals, giving 7,800t of mattresses deposited via HWRC in 2010.

Edinburgh City Council provided historic data on mattresses recycled; including the 2011 data after HWRC deposit by householder was included – rather than bulky waste alone. Bulky waste accounted for 57.5% of mattresses reclaimed, with 42.5% deposited directly by the householder at the site.

4.3.2 FEAT SpringBack

Until late 2011, the social enterprise FEAT operated the 'SpringBack' recycling service of mattresses, handling thousands of mattresses per year. The details of this operation, and the possible reasons for its eventual closure, are detailed in the next phase of the report. However, it is simply worth noting for the purposes of data, that FEAT was

handling around 2,100 tonnes of mattresses in 2010, 1,200 of these supplied by the four local authorities in Scotland reclaiming mattresses[67].

4.3.3 Retailer take-back

The majority of the larger retailers or suppliers offer take-back of mattresses now, though this is often a relatively new service. Ikea, Argos, John Lewis and SilentNight are a few examples of retailers offering this service.

Argos claimed about 20% of mattress customers utilize the take-back service.

Dreams take-back processes approximately 1 in 3 or 4 of their mattresses per year, operating through SITA. Hypnos runs a collection service in partnership with EOL Recycling, and SilentNight, through Exsel. Exact figures were not given, though a minimum of 3,800t of mattresses are known to be disposed of via take-back schemes which included commercial and public sector take-back. The Scottish population accounts for 8.4% of the population of the UK, and applying this proportion to UK take-back suggests 320 tonnes of mattresses are collected by retailers in the country.

4.3.4 Dedicated collection

Some small re-use charities and few of the commercial operators (those on a small scale) offer dedicated pick up of mattresses to the householder, but typically, this is an expensive way of collecting them, as it reduces transport efficiency significantly. No clear figures are yet established though they are considered small. FRN member collection equates to approximately 370 tonnes per year[68]. Based on population ratio, this equates to 31 tonnes of mattresses collected by FRN members in Scotland in 2010.

4.3.5 Other

No other formal collection methods were found for mattresses, although there was some informal exchange between friends/family and even sales online through sites such as eBay. National Bed Federation estimate that 60% of end-of-life mattresses are discarded, the remainder being re-used through an internal pathway such as stated. This would suggest up to 5,800 t of mattresses are being directly sold, re-used or otherwise cascaded to friends/family per year, never actually being 'seen' in the waste stream. Applying the 8.4% of the UK based in Scotland, this gives 490 tonnes of mattresses being informally exchanged through these pathways in Scotland.

Some mattresses are disposed of illegally, and dumped (e.g. at the side of the road) in a process known as fly tipping. Bulky household goods (including mattresses and white goods) make up 50% of fly-tipped rubbish[69], though exact number of mattresses disposed of in this manner is unclear.

4.3.6 Summary of disposal routes

The majority of mattresses in Scotland are still disposed of to landfill, typically through the local authority HWRC site, or bulky collection (which then largely ends up in the HWRC landfill anyway).

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[67] SEPA (2011) Waste Digest Data 2010
[68] WRAP (2012) Textile flow and market development opportunities in the UK
[69] http://www.sepa.org.uk/waste/waste_regulation/fly-tipping.aspx

Table 4.4 Summary of domestic mattress disposal routes in Scotland, 2010

Disposal Route	Tonnage
HWRC/bulky collection to landfill	7,800
Retailer Take-back	320
FRN	30
Informal exchange	490
FEAT	2,100
Other	460
Total	11,200

Other may include some illegal fly-tipping, and dedicated collection of mattresses through non-FRN parties and other re-use schemes (many Scottish local authorities suggest this as an alternative disposal option).

5 Summary

Mattress consumption in the UK is dominated by domestic use, with 134,980 tonnes of domestic mattresses consumed in 2010, 11,200 tonnes of which was in Scotland. Domestic and commercial (hospitality) mattresses are largely sprung mattresses, unlike care homes, prisons and hospital beds, which are typically cellular plastic in composition.

Mattresses can be discarded in a small number of ways, due to their bulky nature, and rarely appear in general household waste (accounting for just 0.01% of residual waste in Scotland in 2008). Waste arisings are seen in local authority HWRC sites in greatest volume, although no authorities in Scotland or the UK as a whole were found to record the actual number of mattresses collected at these sites and estimations placed waste arisings at HWRC in Scotland at 7,800 tonnes, the majority of which are disposed of to landfill. Where mattresses are collected, volumes are recorded, but these typically did not report on source of mattress.

Retailer take-back is significant and growing, with over 7,500 tonnes of mattresses processed through take-back schemes in the UK, including both domestic and commercial users. Recent developments with two of the major agents in this arena have left some uncertainty to future volumes being reprocessed, though this will be further investigated for the next stage of this project.

Non-domestic use of mattresses accounts for approximately 1.58 million mattresses, with just over 1.01 million of these within the commercial (hospitality) sector. These vary significantly in quality, though hotel mattresses in particular may offer a potential useful source of mattresses for recycling. Whilst the volume is smaller than domestic, intensity of arisings may be significant if hotel chains replace several units at one time.

Prisons, healthcare and service mattresses are of lower quality and more likely to be contaminated than those found from other sources.

Appendix III – Scottish mattress recycling capacity

This report describes the infrastructure in place in Scotland and the UK as a whole for the collection and recycling of end of life mattresses

1 Current collection infrastructure

1.1 UK

Collection of mattresses in the UK is sporadic and irregular, with the only national collection schemes in place being those run as retailer take-back. Most mattresses are processed through household waste recycling centres (HWRCs). A few local authorities offer the ability to recycle mattresses, though most do offer bulky waste collection for little or no fee. Many of the mattresses collected via this route are deposited to landfill with others arriving at waste centres.

Although there are no exact collection figures, based upon advertised claims and industry interviews an estimated 25,000 tonnes of mattresses were believed to have been re-used or recycled in 2010.[70] The main recyclers identified in the UK include:

- FEAT Enterprises – 'SpringBack' (Fife, Scotland – no longer operating mattress recycling);
- JBS Fibre Recovery (Telford, England);
- Divert More Ltd (Hartlepool, England);
- Matt UK Ltd (London, England);
- WOW Contract (West Yorkshire, England);
- RMD Mattress Collection (Essex, England);
- Hypnos (now subcontracting processing through EOL);
- EOL Recycling (Preston and Nottinghamshire, England);
- Exsel CIC (Skelmersdale, England)
- Mattress Recycling Group (Grantham, England);
- Dreams (no longer operating own recycling, subcontracting through SITA);
- SITA in Mitcham and Telford, England;
- Carpenters (Derbyshire, England);
- Oran ES (Kilbagie, Scotland); and
- Envirogreen (Co. Armagh, Northern Ireland).

Some local authorities were identified which offer mattress recycling, whether collection or through HWRCs; those that do have recycling schemes located close by. Matt UK and FEAT have been the two schemes which seem to have had the most involvement with local authorities, although FEAT is no longer operating its mattress collection (though Oran ES has taken over contracts temporarily, possibly for the longer term). Local authority involvement varies; some operate their own collection and management with the reprocessor collecting in bulk from the transfer station/HWRC site (as FEAT Enterprises did), whilst others take over the full collection operation. The London Borough of Lewisham Council has a scheme in place whereby dedicated 'mattress crews' collect the items and deposit them directly to Matt UK. All mattresses are collected from the kerbside after a resident has either booked via their call centre or - on the day of the regular refuse collection - placed a sticker on the mattress. (The refuse crew then radios the location of the mattress to the depot, where a job number will be raised for its collection.[71])

[70] Telephone and face-to-face interviews carried out with 13 recycling companies (2 of which are no longer operational)
[71] Personal communication, David Brinson, London Borough of Lewisham, 2012

1.2 Scotland

Of the mattress recyclers listed in Section 1.1, only Oran (based near Grangemouth) operates in Scotland. Previously FEAT had a significant Scottish operation, but this recently stopped taking mattresses, as discussed below.

1.2.1 Former recycling schemes

In 2004, FEAT Enterprises was offered funding from the Scottish Government Executive for three years for a mattress recycling project based in Fife, covering Fife, Clackmannan and Falkirk. The project was to divert mattresses and beds from being sent to landfill. This was the first such project in Scotland and in 2007 was the only one in the UK.

FEAT is a registered charity and this was its third social enterprise project, entitled *SpringBack*. Initially the project was slow to start but, once mattresses were being accepted there was a significant growth. Due to demand for the service, *SpringBack* was required to move after less than one year from 6,000 sq ft premises to a bigger unit of 20,000 sq ft. Mattresses were manually deconstructed, but this was expensive and did not enable units to be processed in sufficient quantities to meet demand. FEAT therefore secured funding from Transforming Waste and the INCREASE Programme to work with a private sector company Ardmel Automations in Fife to develop the "world's first non-shredding deconstruction machine" that would "fillet" the mattress and give 99% recyclability.[72]

The project was considered a success for several years but, as of late 2011, the majority of its assets (e.g. equipment such as forklift trucks and processing machinery) were sold off, and FEAT had to cancel collections from local authorities and other customers.[73] Although FEAT has been unavailable to comment, Oran ES took over several of the organisation's contracts and assets[74], and has started a mattress recycling service near Grangemouth servicing many of FEAT's previous local authority customers. Long term contracts have not yet been established, and the scale of this operation is unclear at the time of writing.[75] Anecdotal evidence suggests that whilst FEAT became very efficient at deconstruction, the machinery developed by Ardmel was not suited to the requirements in the long term due to wear on parts and operational costs, and did not result in high quality end materials. There was also a suggestion from an anonymous stakeholder that, although deconstruction was ongoing, markets for the end materials had been difficult to find; vast piles of sorted, low quality material were reportedly left for long periods in the warehouse, with no end market located.[76]

1.3 International examples of recycling

There are few examples of mattress recycling elsewhere in the globe that take a particularly different form to those occurring in the UK, although some are much more long-lived. The longest running example found was that of St Vincent de Paul, operating in California and Oregon, USA, which was started over ten years ago and claims to have been the first commercially viable mattress recycling scheme in the world.[77]

It has proved difficult to obtain information from European recyclers, even though only a few were identified. Whilst some of the details of economics are unclear, the basic schemes are reported on below.

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[72] The Scottish Government (2009) FEAT Enterprises Available from http://www.scotland.gov.uk/Topics/Environment/SustainableDevelopment/funding/SAGprojects2004/20501 Accessed 11/05/12

[73] Personal communication, several previous FEAT customers, 2012

[74] Personal communication, Jim Cairney, Oran, 2012

[75] Personal communication with Falkirk, Edinburgh and Fife recycling officers, 2012

[76] Confidential personal communication with a mattress recycler, 2012

[77] SVDP (2012) Mattress Recycling Available from http://www.svdp.us/what-we-do/recycling-and-manufacturing/mattress-recycling/ Accessed 09/07/12

1.3.1 St Vincent de Paul, USA

Between two sites in Oakland, California and Eugene, Oregon, the not-for-profit organisation handles over 120,000 mattresses and box springs (cloth-covered wooden base with springs – common in America) every year.[78] It is claimed that all materials are recycled, excluding approximately the 4% which have been not found an end use. Only 0.05% of mattresses which arrive at the site are rejected completely, typically because they have been somehow 'mangled' or are completely wet and have no value.

Deconstruction is manual, with mattresses cut open by hand, and materials separated and baled for recycling (including cotton, wood, steel and foam). According to the organisation, whilst there are still difficulties with 'flocking'-style textile material, cotton is more commonly used than in the UK, and there are more end markets for this. However, it was noted that markets develop as the need for them grows and, while ten years ago there was no market for the baled cotton found in mattresses, this has evolved as more mattresses have been processed.[79]

The Oregon site opened more recently, and operates on a smaller scale, than the Californian one. Oregon employs four people, and handles 40-50 mattresses per week, whilst California employs 15 people, and handles 120-140. The material has the greatest value when manually deconstructed, and the company moved away from automated deconstruction after a short trial proved it to be unsuitable. The scheme is still only viable with a service fee, typically $6 per mattress, from waste companies and local authorities.

1.3.2 Mattress recycling in Canada

A landfill ban on mattresses in Canada in 2011 has resulted in several companies operating systems, two of the largest being MattCanada and Canadian Mattress Recycling. Both these schemes currently use manual deconstruction processes, although MattCanada has recently been experimenting with novel equipment which may make the process easier and more efficient. The equipment is not being used because the project was never completed, though the details are unclear.[80,81] (This is discussed further in Section 2.3.2.)

MattCanada charges $14 to recycle a mattress (plus delivery if customer is unable to drop off the mattress at the site); Canadian Mattress Recycling charges $12 for residential or $11 for commercial (though this is variable dependant on scale). The latter also will take commercial mattresses for $14 if wet/soiled, to cover the cost of disposal, other organisations may charge more.[82] Canadian Mattress Recycling can recycle almost 100% of a clean, dry mattress can be recycled. In 2011 approximately 90% of the 28,000 mattresses collected were recycled, the 10% waste proportion being rejected largely due to contamination, dirt or wetness.

1.3.3 Ares Recycling, Germany

Ares Recycling GmbH & Co. KG is a commercial mattress, foam and plastics recycling company based in Schongau, Germany. Established in 2006 in Neumünster, this organisation also collects mattresses for manual dismantling, separating individual components with particular focus on PU foam, steel and latex.[83]

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[78] SVDP (2012) Mattress Recycling Available from http://www.svdp.us/what-we-do/recycling-and-manufacturing/mattress-recycling/ Accessed 09/07/12

[79] Personal communication, Terry McDonald, SVDP, 2012

[80] Personal communication, Joel Chateauneuf, MattCanada, 2012

[81] Canadian Mattress recycling have developed deconstruction equipment for box spring type mattresses; however this is not relevant to the UK.

[82] Personal communication, Terryl Plotnikoff, Canadian Mattress Recycling, 2012

[83] ARES (2012) Mattress recycling: Single fraction. Available from http://www.ares-recycling.de/default.cfm?mid=34881

1.3.4 Recyc-Matelas, France

Recyc-Matelas Europe is part of a wider scheme incorporating America and Canada, with the European site currently based only in France. Old mattresses are cut up in order to collect all the raw materials: metal, wood, cotton, felt, polyurethane and fabric. These materials are then sent to other companies to give them a 'second life'.
An old mattress can be recycled into secondary material, which is used in cars, as well as for mulch and carpet underlay among other things.

The company highlights that not only are mattresses largely recyclable, but they also cause serious problems for landfill operators. The problem suggested is that mattresses are not sufficiently crushed in the 'first stage' of waste handling, so they need to be passed through a roller-compactor (a truck with a roller on the front which compresses things in its path). However, because mattresses fold and unfold so easily, "like sponges", they often spring up again after being crushed. This therefore means they may have to be recrushed again and again or removed from the site. Without crushing, the space required for a single mattress is significant.[84]

1.3.5 IOK, Belgium

IOK is a waste management company based in Belgium which manually deconstructs around 80 mattresses per day. Mattresses are collected from containers (at waste parks) on a 'milk round' style system, and are stored in dry conditions. IOK charge €10 per mattress, each yielding on average €1.60 from materials.[85] As in the UK, the key recyclate desired is the steel, which amounts to 8kg per mattress. IOK is currently researching other recyclate markets, in particular the 'stuffing' textile.

1.3.6 Retour Matras, Netherlands

Dutch mattress waste arisings are approximately 1.2-1.5 million per year, and Retour Matras currently handles 100-120,000 of these, with a current capacity of 190,000 pieces. The system used is fully automated, and works effectively for 95% of mattresses. Manual deconstruction is required for the 5% which are constructed with unusual materials, such as wooden frames, or flax filling, which need individual attention, or have higher use of glued components than typical. Mattress composition is different to that typically found in the UK, however; only 30-40% are sprung mattresses, the remainder being largely foam or latex.[86]

Retour Matras' innovative system was designed in-house; the company is looking to develop a market for the equipment, to export to other countries also wishing to recycle mattresses. The equipment is discussed in greater depth in Section 2.3.1.

Transportation is a significant cost for the system and, to reduce this, further plants are planned for around the country. In the meantime, the company minimises costs by collecting at municipal waste collection stations in containers (90 pieces per container); retailers are collected from by courier, who handle a minimum of 10 pieces which are deposited at the collection points. As a result no long distances are travelled other than by full container-loads.

The key competition for the company is incineration, which costs €60 per tonne in the Netherlands; however, Retour Matras claims that mattresses are a problem product for incinerators. Mattresses, if not correctly pre-processed, can create hot spots on the incinerator grits and have negative impact on the flue gas quality and bottom ash quality.[87]

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[84] Recyc-Matelas (2010) The importance of recycling (video on website, in French only). Available from http://www.recyc-matelas.com/en/mission
[85] IOK Afvalbeheer (2011) Zachte landing voor matrassen presentation given to the Waste Congress
[86] Personal communication, Anne Booy, Retour Matras, 2012
[87] Personal communication, Anne Booy, Retour Matras, 2012

2 Mattress disassembly

In order to obtain component parts and materials from mattresses for recycling, mattresses need to be disassembled by some means. Limited mechanical disassembly is possible with current technology, although some recyclers do use machinery to varying degrees of success.

2.1 Manual deconstruction

Mattresses are generally made up of three layers[88], as follows:

- core (inner steel springs or foam);
- shell (padding – usually foam or textile, or both); and
- tick (textile covering).

In order to collect the individual components, these layers need to be separated. This can be complicated by the different types of construction used to attach the layers – for example the shell and tick may be stitched together, and may consist of several layers of different materials. The core may be glued, stitched or stapled into place, and may have springs individually contained within pockets of cotton or other fabric. A basic manual deconstruction may involve either one or two workers slicing through the ticking with a Stanley knife or similar. This layer is peeled back and, if possible, stitches holding the textile and foam layers together can also be sliced, allowing the worker(s) to pull apart the different materials, which are separated into specific areas to be baled later. (Figure 2.1 exemplifies the difficulties in separating the materials; it shows mattress ticking which has six layers with intricate, tight stitching holding the middle three together. It would not be economically feasible to cut stitching of this nature, due to the time it would take.)

Figure 2.1 Example of the multiple layers and materials present in mattress ticking

Source: Mattress ticking removed by one mattress collector for recycling

[88] For more detail, see WP2: Zero Waste Scotland (2012) Mattress Recycling: Scottish Infrastructure Business Case Work package 2 – Arisings and disposal routes of mattresses in Scotland – as yet unpublished

The remaining core may still have attached foam or flocking-type material; this is torn or removed from the structure for separate collection, and the steel springs can then be gathered for recycling.

2.2 Shredding

The quickest way to deconstruct a mattress is simply by to process it through a shredding machine. These heavy duty machines are solid metal containers with a wide aperture leading to rolling blades and/or teeth to tear through the mattress. The shredder pictured in Figure 2.2 would cost £80,000 new from the original equipment manufacturer (OEM).

Figure 2.2 Enerpat MSC-41 Mattress shredder

Many organisations have reported two problems hindering the success of mattress recycling using shredders, however. Firstly, the sprung steel is very hard (harder than the hardened steel typically used in recycling machinery), has a light gauge (i.e. is thin) and can chip and blunt the blades, and get stuck between them, causing shredder jams and expensive maintenance fees. Secondly, because the metal is pulled out of the mixed material after processing, the end product is not of the highest quality, which restricts the end markets to which it can be sent (see Section 5).

There are exceptions, however; whilst Dreams has itself stopped collecting and processing mattresses (because of high maintenance costs of the equipment), it has contracted-out mattress processing to SITA, which processes mattresses at two material recycling facilities (MRF) sites, Mitcham and Telford, using shredding equipment. SITA invested in this equipment in the full knowledge of Dreams' past problems. With its experience of handling many different waste streams and with the potential to invest in large-scale equipment, SITA invested in Doppstadt machinery, which, according to site manager Ian Kelley, is better suited to the job it is required for.[89] This has not overcome the quality aspect, however, and the flocking/textile/foam output is currently used as temporary landfill cover. SITA is planning to design new bespoke equipment, better suited to mattress deconstruction without devaluing the end material outputs.

[89] Personal communication, 2012

2.3 Other separation equipment

Whilst no UK facilities appear to be using highly advanced technology for mechanical deconstruction, several examples of the use of unusual equipment have been identified outside of the UK. In each of these examples, the equipment appears to have been designed by the company using it.

2.3.1 Whole mattress deconstruction and separation at Retour Matras, Netherlands

This bespoke system involves a dedicated facility with substantial operating space. The company collects mattresses from various sources, providing containers to keep the units dry and clean. These containers are then transported to the facility once full and the mattresses deposited (see Section 1.3.6 for more detail).

Only four staff are required per shift. An electric crane is used to move the individual mattresses from the deposit point onto a moving conveyor, where they are aligned and moved through an in-built metal detector. At this point non-metal and metal based mattresses are separated.

The mattresses then pass through a machine which cuts along the edge of the mattress. A specially developed 'peeling roll' then removes the outer textile 'sleeve', which is sent for separate baling (though it is not clear what is the end application for this material). Large vacuum extractors minimise dust collection from the textile elements.

Metals are then removed with the use of magnets, and the foam is sent for further cutting into manageable pieces, and collected. Again, this is under extraction to minimise dust contaminating the end products which are sent either for filling for furniture (latex) or underlay and insulation (if polyurethane).[90,91]

Figure 2.3 Mattress sorting and processing system, Retour Matras, Netherlands

Source: http://www.retourmatras.nl/index.php/2011/02/matrassen-recyclen-voor-het-herwinnen-van-grondstoffen/?lang=en

[90] Retour 100% mattress recycling (2011) http://www.youtube.com/watch?v=l3ph9lE-RQ4&feature=related

[91] Retour Matras Recycling Process. Available from http://www.retourmatras.nl/index.php/recycling/?lang=en Accessed 30/05/12

2.3.2 Mattress dismantling system at MattCanada, Canada

MattCanada produced an innovative roller system which reduces the manual deconstruction required in other systems. This prototype is shown on the internet as a working model[92], requiring a mattress to be stood on its side and manually fed into the machine, which appears to be based on two cutters fed from rollers moving the mattress through the machine. This results in a fairly clean spring-set, and a top and bottom layer of foam and textile. These require to be manually removed from the machine. The details of the project were not clear but, according to MattCanada, the machine was never integrated into daily use, and was never progressed from prototype stage.[93] It is included here as an example of innovation being attempted in the sector.

2.3.3 Sleeve removal at Envirogreen, Northern Ireland

Rather than attempting to separate all components by machine, Conor Guy of Envirogreen Recycling suggested automating only one aspect of deconstruction: the de-sleeving of the mattress. As many internal components vary (mattresses may have pocketed springs, foam may be stapled to the frame etc.), trying to create a machine to cater for all types would be quite complex. However, the textile outer covering is a common feature, so mattresses are simply passed through a bespoke machine which runs cutters along the edge and removes the sleeve. Whilst the final deconstruction is done by hand, this machine has reduced the time taken for complete deconstruction from 5-6 mattresses per hour per person, to 10-15 per hour, significantly increasing potential throughput.[94]

2.4 Additional equipment required

2.4.1 Balers

Balers can be used to compress individual component materials, such as foam sheets or textiles, into smaller bales ready for transportation, and are critical to efficient transportation and use of warehouse space. Balers range significantly in price, depending on exactly what is required. For example, whole mattress balers which may be used on some automated shredding systems are quoted as ranging from £12,500 to £20,000[95], whilst other sources suggested a large baler would cost £45,000, or a small vertical baler £8,500.[96] One company suggested that second-hand balers for small processing purposes can be easily sourced for approximately £5,000.[97]

2.4.2 Compactors

A compactor takes the air out of springs, providing more efficient transportation of the metal, allowing for higher value to be obtained. This machinery is expensive, and considered inaccessible to many of the smaller operators, with estimations at £150,000 for a second hand unit[98]. This can increase the value of steel from £70/tonne to £220/tonne, however, so if enough processing is carried out on site, then this could be a beneficial investment.

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[92] Youtube - MattCanada (2009) Mattress dismantling system available at http://www.youtube.com/watch?v=NA0fqT9IL9g accessed 21/04/12
[93] Personal communication, Joel Chateauneuf, MattCanada, 2012
[94] Personal communication, Conor Guy, Envirogreen Recycling, 2012
[95] Marketing material, Enerpat, 2012
[96] 3RDeconstruction (2010) A Solution to Lancashire's end of life mattress problem
[97] Martin Gamester, Exsel CIC, personal communication 2012
[98] Estimated cost, Nick Ottinger, EOL Recycling, personal communication, 2012

Figure 2.4 Springs from a kingsize bed, compacted

Source: Anonymous mattress recycler, 2012

2.4.3 Forklift trucks

Forklift trucks are necessary to move bales of processed materials around the site, to load and unload lorries, and to move any heavy goods. The number of forklift trucks required varies depending on the size of the operation. A single forklift truck will cost approximately £2,000-£7,000 depending on lifting capacity.

2.4.4 Turn-tables

Turn-tables are pivoting surfaces that allow a mattress to be spun by hand, which helps with the deconstruction if disassembling mattresses by hand. Their usefulness is debated by some industry members: One company stated that turn-tables did not increase the efficiency of deconstruction but led to higher chance of injury, due to design.

2.4.5 Extra equipment

Where shredding equipment is used it can be hand-fed, or linked to conveyor belts feeding the mattresses automatically into the shredder. An overband magnet may be used to remove the metallic element of the shredded material, leaving a resulting product consisting of mixed textile, foam (latex and PU), and any other materials present such as coir, horsehair etc. A full system with conveyor-fed shredder and magnet was priced at £84,000 by one manufacturer, although this also required additional mattress balers to feed the system.[99]

3 Business models

Several business models exist for mattress recycling, with key considerations including;

- Where are mattresses sourced from?
- Is processing manual or automated?
- Is this social enterprise or purely commercial?

All known initiatives included a fee for the service, with the only variation being how much and whether this was charged to the user/local authority/etc (the latter paying significantly lower than those services directly charged to consumers, with contract consumers being an exception).

[99] Enerpat, Complete Shredding System that includes: In-Feed Conveyor, MSB55 Shredder, Exit Conveyor, Overband Magnet, marketing material, 2012

Each of the stages is considered below, with benefits and barriers of each alternative considered.

3.1 Sourcing of mattresses for recycling

There are several options available for mattress collection and sourcing, depending on the original market. These are listed in Table 3.1, over, along with the benefits and disadvantages of each.

Individual trips for collection of mattresses directly from the consumer is cost-inefficient, and requires significant time also. Companies collecting mattresses on behalf of a local authority are likely to collect in greater numbers and, if they handle other bulky goods, can include this in their service to the local authority thus increasing cost-effectiveness through transport efficiencies.

Manufacturers and suppliers are beginning to become aware of the need to recycle mattresses not only for environmental concerns but also because of the rising cost of landfill. Retailer take-back - whereby suppliers collect old mattresses when delivering new on a 'back haul' system - is convenient from the point of view of logistics, but this is a rare event. The fragmented nature of the sector, with numerous small suppliers, is not conducive to recycling; economies of scale are required for recycling to be feasible. There is also a misunderstanding of Health & Safety Legislation; manufacturers cite this as the reason they are not allowed to remove old mattresses on vehicles with new.[100]

It is critical, to maintain the value of materials, that the mattress is kept dry. This is also important for manual handling and health and safety, as otherwise the mattress may become mouldy and rotten. Where mattresses are collected at HWRC sites, for example, they must be kept clean and sheltered from the elements.

[100] Personal communication, Jessica Alexander, National Bed Federation, 2012

Table 3.1 Sources of mattress and key types of collection seen in the UK

Original source	Collection type	Benefits	Disadvantages	Comment
Domestic	Via retailer take-back.	Use of backhaul.	Not controlled by reprocessor – potential value loss.	Can limit the need for waste carriers licence if mattresses deposited by retailer at the site.
	Local authority bulky waste – third party.	Collection of multiple units from single (or minimal number of) site(s).	Not controlled by reprocessor, and collected alongside potentially damaging and waste goods– potential value loss. Storage at centralized site can be poor.	Quality of goods can be maximized by providing storage containers for the HWRC/transfer station etc.
	Local authority bulky waste - direct collection.	Control over packing and storage. Large customer base as all LA customers.	Inefficient transport use, single trips for collection (unless also taking other bulky goods).	
	Dedicated collection by reprocessor.	Limited customer base.	Inefficient transport use, single trips for collection (unless also taking other bulky goods).	
Commercial	Via retailer take-back.	Use of backhaul. Operator can either collect from central depot, or have deposited by retailer at a specific site.	Anecdotal suggestion of 'best' items held back by collection agent.	Can limit the need for waste carriers licence if mattresses deposited by retailer at the site.
	Dedicated collection by reprocessor.	Larger collection numbers at single site may offer greater efficiency than equivalent domestic set up.		
Public sector	Via retailer take-back.	Use of backhaul. Operator can either collect from central depot, or have deposited by retailer at a specific site. More specific mattress types – for example foam use high, retailer can reprocess directly.[101]	When considering healthcare collection, measures need to ensure no potential cross contamination of soiled mattresses and new.	Can limit the need for waste carriers licence if mattresses deposited by retailer at the site.
	Dedicated collection by re-processor.			

[101] For example, Carpenters supply MOD mattresses of foam, and take these back to recycle into underlay at end-of-life – personal communication, 2012

3.2 Manual vs automated

Although individual steps of the process may be automated in other parts of the world, in the UK shredding and manual deconstruction are currently the only processes employed. No fully automated facilities for mattress recycling were found within the UK, and therefore it in not possible to comment on the economics of the process. The only company in the world known to have a fully automated system is based in the Netherlands (see Section 1.3.6). This system appears to be suitable for Dutch mattress construction but, given the higher proportion of sprung mattresses in the UK, the feasibility of using such equipment in the UK would require further research.

The use of shredders has been linked with high maintenance cost and low material quality; issues that have been linked to the demise of several mattress recycling schemes, including those run by Dreams, Hypnos, and FEAT. Shredder blades can damaged by the tough mattress springs, and the shape of the spring results in pieces of metal sliding between gaps in equipment and jamming the blades, resulting in frequent down-time of equipment. The alternative, however, is highly intensive of man-power and requires a large amount of space. All re-processors interviewed, including several overseas, agreed that manual deconstruction leads to the best value from end outputs, and many of the long-term successful projects, such as St Vincent de Paul in California and Oregon, actually started with the use of shredding equipment and found this to be ineffective due to cost and quality of materials salvaged.

3.3 Commercial vs social enterprise

Because of the high man-power requirement of manual deconstruction (*inter alia*) many projects were found which disassembled mattresses on a small scale and involved volunteers. Those interviewed had business models, and were run as profitable enterprises, but were able to minimise some of their labour costs by using volunteers. One such organisation, Exsel CIC, explained that it wished - eventually - to pay its entire staff, but until the income from material has increased it is unable to do so.[102] Commercial operations involving manual deconstruction do exist (such as JBS Fibres and, to some degree, Envirogreen Recycling in Northern Ireland - though this is semi-automated) although throughput of these sites is larger and therefore economies of scale can be realised.

3.4 Other considerations

A key consideration when designing the business model is the cost of the service to customers. The revenue available from materials (Section 5), the cost of set-up, labour and equipment (Section 0), and the low cost of landfill for bulky items all influence this decision. Local authorities have limited budget available and, when recycling costs significantly more than landfill, it can be rejected. This can be balanced if the work is carried out by a charitable organisation. For example, the City of Edinburgh Council explained that it paid FEAT Enterprises for recycling, as FEAT was a social enterprise and offered social benefits beyond simply recycling and diversion from landfill; the same price is unlikely to be paid to purely commercial operators.[103]

According to stakeholders, charges to local authorities can be as little as £2.50 per mattress, ranging to £7-£8.[104] FEAT, for example, charged £5 per single and £6 per double mattress, which equated to £180 per tonne for one local authority.[105] The cost paid to the local authority by the householder varies, with many HWRC sites allowing disposal for free and offering to uplift bulky items for between £0-£25/30 (for up to around 5 items per lift).

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[102] Personal correspondence, Martin Gamester, Exsel CIC, 2012
[103] Personal communication, Karen Storrier, Edinburgh City Council, 2012
[104] Input from several mattress recyclers and local authorities, 2012
[105] Personal communication, Caroline Mooney, Stirling Council, 2012

Retailer take-back is often charged at a higher rate, as the cost can be pushed further along to the consumer. Retailers and suppliers reported charges between £15 and £39 for take-back on delivery of a new bed, although this may allow for uplift of several pieces such as whole bed frames etc. Exact charges paid to the repressor by the retailers are obscure due to commercial confidentiality, though believed to be in the range of £8-£12 per unit.

4 Current and potential capacity of current operations

4.1 Current capacity

Mattress recycling is a relatively new market in the UK (although it is not new globally; sites in the USA have been operating for over a decade). Several of the companies currently operating have substantial ambition and opportunity for growth, and those interviewed mentioned several (confidential) expansion plans which may increase the current capacity. Confidential interviews with recyclers suggested that, in 2010, approximately 1.9 million mattresses (equating to almost 25,000 tonnes, or 15% of arisings) were processed. The limiting factor for growth is not considered to be feedstock supply; rather, it is often the end market applications. For example, where the revenue for steel is low and the transport distance of the un-compressed springs is long the economics are unfavourable.

Figure 4.1 shows the location of the key mattress recyclers known to be in operation in the UK in 2011, shown colour-coded by quantities of mattresses handled (in tonnes). Several manufacturers were hesitant to give detailed information on volumes, and therefore ranges have been given to indicate size of operation. It is clear from the Figure that limited recycling operations are in place in Scotland, especially outside the areas around Glasgow/Edinburgh. The green peg represents FEAT, which is no longer operational (as discussed in Section 1.2.1), and the second site represents Oran ES, which has started to collect mattresses, but was not operational in 2011 and therefore cannot be mapped by size. This is also the situation for sites in Trowbridge and Burton-on-Trent, opened by JBS Fibres in 2012.

A more recent review suggests that mattress recycling in 2012 is likely to be less than 25,000 tonnes (a figure which was queried by several stakeholders). The industry appears to be difficult to understand accurately, as there is much wariness with regard to commercial sensitivity and recyclers were often hesitant to give too much detail of their own practices. At least one of the large recyclers of mattresses has terminated operations since 2010, and another, responsible for a significant number of mattresses, stated in interview that it was not currently collecting mattresses. Two further retailer take-back schemes have been sub-contracted out to new operators, though the effect on overall collection volumes appears to be minimal.

Furniture re-users (often social enterprises and charities) may collect beds and donate the mattresses to those who need them, or else sell them on for reduced price, but this operation is considered small in comparison to use of dedicated collection routes; fewer than 400 tonnes were re-used by Furniture Reuse Network (FRN) members, interviewed in 2012.[106] Whilst this is a small tonnage when considered against the total arisings, it is worthy of note as re-use is considered higher on the waste hierarchy than recycling.

[106] Confidential survey of FRN members for the MPD005-003, Furniture mass flow, 2012

Figure 4.1 Distribution of mattress recyclers in the UK, by tonnage handled

Key: (Tonnage per year)

2,001 to 5,000
1,001 to 2,000
501 to 1,000
2 to 500
Not operational in 2011

4.2 Future trends and developments

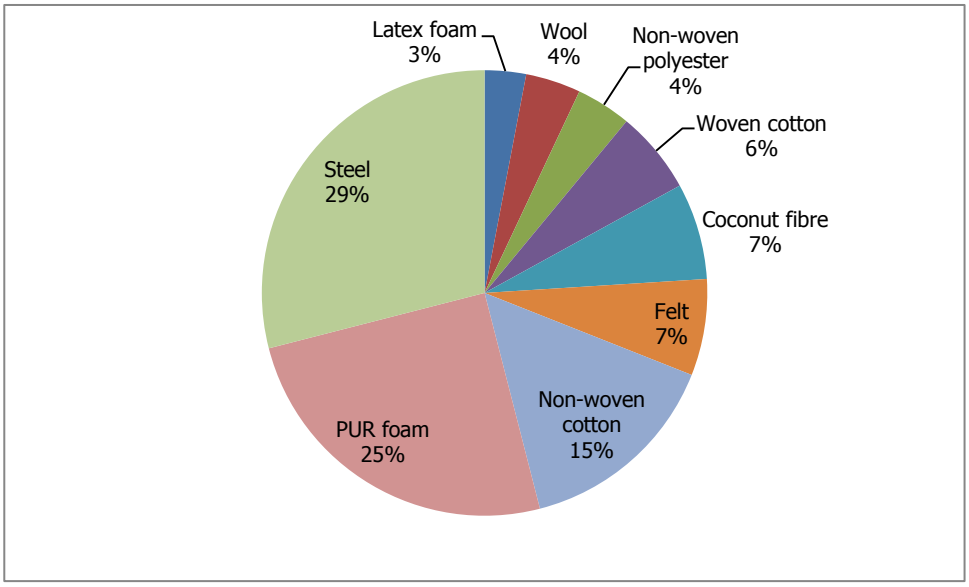
JBS Fibres, the largest collector of mattresses in the UK, reported handling 265,000 pieces in 2011, but recent figures have suggested current collection of 500,000 mattresses.[107] In 2012 the company expects to collect 1 million, with new sites having opened in Burton-on-Trent and Trowbridge. Divert More has been developing an innovative new scheme to expand its collection and handling capacity. Although currently confidential, plans include a site move, followed by expansion to initially one or two more sites, each with the capacity of approximately 1,000 mattresses per week. The sites would operate manual deconstruction, with 100% landfill avoidance. The first of these sites is already in preparation for launch, and is expected to be operational in the near future.[108]

Oran Environmental Solutions has only recently established a recycling scheme near Grangemouth, Scotland, and is currently in negotiations with some of the local authorities within the area, and has begun rolling this out as a service to further authorities in the future.[109]

5 Markets for the disassembled mattresses materials

There are many individual materials used in mattress construction, and these are discussed in greater depth in WP2.[110] The main components include: steel, cotton (approximately 10% unwoven), polyester, wood, foam, mixed textile cover layer and flock. Markets for these depend greatly on the quality of the material, including contamination level and moisture content. UK mattress waste includes 49,000 tonnes of steel, over 42,000 tonnes of PU foam, and over 25,000 tonnes of cotton.[111] For the 14,000 tonnes of mattress waste arising in Scotland, this equates to over 4,000 tonnes of steel, 3,500 tonnes of PU foam and approximately 2,100 tonnes of unwoven cotton (Figure 5.1).

Figure 5.1 Material arisings from Scottish mattress waste stream, 2011 (in tonnes)



[107] JBS Fibre (2012) Who we are Available from http://www.jbsfibre.co.uk/who-we-are/ Accessed 16/07/12
[108] Personal communication, Matthew Stephenson, Divert More, 2012
[109] Personal communication, Jim Cairney, Oran, 2012
[110] Zero Waste Scotland (2012) Mattress Recycling: Scottish Infrastructure Business Case Work package 2 – Arisings and disposal routes of mattresses in Scotland – as yet unpublished
[111] Based upon composition discussed in Zero Waste Scotland (2012) Mattress Recycling: Scottish Infrastructure Business Case Work package 2 – Arisings and disposal routes of mattresses in Scotland – as yet unpublished

Fabrics and other materials may be attached (stitched, glued or stapled)[112] and deconstruction can be difficult.

A number of companies look to sell the higher value materials such as steel and polyurethane into the scrap market, but redirect lower scrap value materials such as textiles into new manufactured products, thereby adding value. Whilst landfill costs are high, the mattress materials are relatively light for their bulk and landfill is often a less expensive option due to limited markets for some of the materials. This is considered to be a perception issue of hygiene factors rather than a technical issue.

5.1 Re-use

Many charities and social enterprises collect mattresses (often along with other furniture) for re-use by less advantaged families and individuals. These may be donated, or sold in discount second hand stores and charity shops; mattresses (in good condition) are in short supply, and are highly sought after.[113] Financial gain from these mattresses is minimal, as there is limited value from resale due to the nature of the market and target customer, and also the perceived value. Because the sector is selective of mattresses for re-use, 75% of 'second-hand' mattresses collected for re-use end up being re-used and the remaining 25% are disposed of to landfill - a costly issue for businesses. This is not to suggest that 75% of all mattresses are suitable for re-use, however, as only those mattresses which meet the collecting organisation's standards are collected, to minimise the need for disposal at a later point.

Reprocessors working with retailers' rejects (due to customer returns, minor damage from transportation etc) receive good quality, unused mattresses which have a higher resale value. Exsel CIC collects mattresses from SilentNight, both take-back items and returns, and approximately 65% of the units are unused.[114] Retailers are not able to sell mattresses that have been returned, even when unopened – for example due to the wrong colour/model being delivered – which means that the items requiring disposal are sometimes in perfect, unused condition. Many pass these on to resellers with the proviso that any labelling is removed. A significant benefit of selling these 'new' units over true 'second-hand' ones is that the fire regulation safety certificates are still in place and untouched, whereas these are often removed or faded on old mattresses.

5.2 Steel

Steel is highly recyclable, and fetches between £180 and £220 per tonne (based on the January 2012 scrap steel report[115]) but, according to one mattress recycler, sprung steel does not fetch as high a price as mild steel, and springs if not compacted (due to transport inefficiencies) can fetch as little as £70 per tonne. Market demand for recycled steel is high, with 42% of the steel that makes new products sourced from recycled steel.[116] This is expected to be a continuing market, and one of the most valuable components of the mattress.

5.3 Polyurethane foam

The global PU market has seen growth over recent years due to expansion into many applications (including rigid and flexible foams, adhesives and sealants, amongst others). The global PU market had a value of over US$40 billion in 2011, and is expected to reach US$57.4 billion by 2016.[117] The key restraint in the PU market is rising prices of raw

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[112] See Appendix I, page 66

[113] Survey of FRN members by Oakdene Hollins, 2012

[114] Personal communication, Martin Gamester, Exsel CIC, 2012

[115] WRAP Materials pricing report (2012) for scrap steel

[116] British Metal Recycling Association (2010) About Metal Recycling Available from http://www.recyclemetals.org/about_metal_recycling

[117] Transparency Market Research (2012) Polyurethanes (PU) Market: Global Industry Analysis, Size, Share and Forecast (2009-2016)

materials derived from crude oil, such as benzene and toluene. This could theoretically increase demand for recycled polyurethane.

PU is recycled primarily via two routes: mechanical recycling, in which the material is re-used in its polymer form; and chemical recycling that takes the material back to its various chemical constituents.[118] Most typically, for those recyclers interviewed, PU foam from mattress filling is used for 'rebonding'. The collected foam is chopped and shredded into small pieces and then mixed with a binder under heat and pressure to form logs or blocks that then are peeled, sliced or diced like other polyurethane foam, for carpet underlay, sports surfaces etc. Other applications for recycled PU foam include pet bedding, gym pads, matts and – potentially - back into mattresses (this was listed as a theoretical possibility, though no known examples were found).[119]

Scrap PU prices vary considerably depending on its source, condition and supply capability, but in general are between US$200- 800 per tonne[120], equating to approximately £130-520 per tonne. However, one recycler confidentially stated the highest value it found for mattress PU foam was £100 per tonne.[121]

5.4 Latex foam

Latex foam should not be confused with PU foam; whilst there are similarities with the end products they are produced using different methods and different materials. Latex foam may be made from either synthetic or natural latex rubber, or a combination of the two. However, like PU foam, latex foam rubber reclaimed as manufacturing scrap or from post-consumer use can be chopped and utilized when mixed with polyurethane scrap as bonded carpet cushion. Latex foam rubber generally has a relatively high density and is soft, thus latex foam rubber can only be used in limited amounts in the production of bonded carpet cushion.[122]

5.5 Textiles

The textile components of mattresses include unwoven cotton, polyester and mixed textiles within both the flocking material and sometimes the ticking itself. Flock is typically produced from old clothing rags, hence the mixed textiles in mattresses may include any textile used in apparel, including linen, wool and nylon for example, although wool is often present due to its natural flame retardancy.

JBS Fibre Recovery recycles 100% of mattresses collected, including all textile components. Whilst it is claimed that the textile can be converted into acrylic and polyester fibres, wool blended yarns, polyester textile yarns, woollen shoddy yarns and a range of PU foam-based material including a high context carpet underlay product, the specifics of the conversion technology are not clear. The production of finished product (including carpet underlay and textile products) is preferred as this gives higher value than baled waste material; however, no details were given due to commercial sensitivity.

Textile materials for shredding have an average value of around £88 per tonne[123], though this tends to be for use in mattress filling and similar. Mattress mixed textile was described as one of the 'problem materials' by several

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[118] American Chemistry Council (2012) Polyurethane Recycling Available at http://polyurethane.americanchemistry.com/Sustainability/Recycling accessed 21/05/12

[119] American Chemistry Council (2012) Polyurethane Recycling Available at http://polyurethane.americanchemistry.com/Sustainability/Recycling accessed 21/05/12

[120] Varying industry exchange sites, correct at time of writing, June 2012

[121] Confidential personal correspondence, UK mattress recycler, 2012

[122] Polyurethane Foam Association (2000) Intouch: Latex Foam Rubber and FPF: Different Product Technologies With the Same Comfort Objectives

[123] WRAP (2012) Textiles flow and market development opportunities in the UK

reprocessors, though examples of end applications were found. One flocking manufacturer stated that, whilst the material could – "technically" - be put through their system and recycled back into flock relatively simply, they would not handle it due to consumer perception. The use of textile from old mattresses was considered likely to "put off" customers.[124] This lack of demand also limits the price for baled textile, although one mattress recycler has overcome this by producing its own added-value secondary products; bringing the next stage 'in-house'[125] rather than selling bales of textile for processing.

Commercial sensitivity in the sector is high, and few reprocessors wished to divulge actual end-user details, for fear of competition; however, examples of use in automotive felts, fillings for cushions and pet bedding were given. One recycler exports the material to Pakistan and India, but as it is not able to ensure the consistency of the bales, both of these markets have ended up rejecting them.[126]

According to one recycler, the automotive felt market is known to offer approximately £50 per tonne for needle-punched material (a non-woven material, used in mattress felts and padding, created by mechanically interlocking fibres), but this is again dependent on quality. The textile rag available from clothing is relatively easily available (even if sourced from overseas), making the market competitive and pushing prices down, so that some organisations are obliged to "give this material away" for very little.

The pure polyester layer found in some mattresses has a high potential value, with one recycler claiming current markets offer up to £160 per tonne (though typically the price is closer to £100). Because this layer is made of polyester only, and due to the limited processing of the polyester before use, the polyester fibres are long and their suitability for recycling is high.

5.6 Wood

Wood reclaimed from mattresses (and, more typically, mattress/divan bases) is generally used for chipboard or fuel. FEAT Enterprises reported that wood was ideal for making kindling for wood stoves etc. and was taken by a major fuel distributor. FEAT also began to produce prototype biomass products, such as a briquette from the flock in mattresses (with a calorific output rating of 6.5 kJ/g) and coir/wood pellets (with an output rating of 7.5kJ/g).[127]

Wood can also be processed into mulch for use in garden landscaping and similar.

5.7 Other materials

The proportion of residual waste from mattress deconstruction varied by recycler, ranging from approximately 33% to claims of zero waste by others. Materials which arise in smaller volumes, including coir and horsehair (approximately 7%, fewer than 1,000 tonnes in Scotland), may be disposed of to compost-making, though small scale enterprises may find this impractical if there are no facilities to do this locally.

5.8 *Intrinsic value of mattress materials*

The materials discussed in the previous sections are summarised in Table 5.1, over. It is clear from the Table that the largest potential revenue is available from the steel and PU foam, although the variation in price available for these two

[124] Personal communication, David Mulligan, Edward Clays & Sons, 2012
[125] Personal correspondence, confidential, 2012
[126] Confidential personal correspondence, UK mattress recycler, 2012
[127] The Scottish Government (2009) FEAT Enterprises Available from http://www.scotland.gov.uk/Topics/Environment/SustainableDevelopment/funding/SAGprojects2004/20501 Accessed 11/05/12

materials means that the difference between the highest and the lowest possible realisable values for these two component materials alone is over £700,000. This highlights the need for high quality separation of these components, and development of effective compaction equipment for the steel springs.

The textile element is simplified in Table 5.1, due to the huge range of prices received for varying levels of quality, and of end markets. Many companies have had difficulty finding end markets; this results in otherwise recyclable materials being disposal of to landfill, which is costly. Losses associated with this may be even higher if the material has been shredded and no end market is found for higher value components such as the polyester.

Table 5.1 Summary of key material values and end markets in Scotland

Material	Value	Tonnes	Total potential value (£)	Applications	Comment
Steel (compacted/ processed)	£180-220	4,060	284.2 – 893.2	Remelt for use in any traditional steel applications	Steel is highly recyclable, and current demand is high.
Steel (in spring format)	£70-100			Remelt for use in any traditional steel applications	Transport of springs is highly inefficient, due to high volumes of air being moved. Value therefore varies largely due to distance from steel merchant.
PU	£100-130 (up to 520 theoretically)	3,500	350 – 455 (1,820)[128]	Carpet underlay, sports surfaces	The value of PU varies considerably depending on the source, quality and supply capability.
Latex	£0-100	420	0 – 42	Packaging and carpet cushion	Latex has end outputs which are technically similar to PU, though they lack some of the properties, and therefore are not typically as easy to find end markets for. One recycler sold latex foam with PU, which devalued the PU, but allowed for high value from latex.
Textile	£-64 - £88	3,640	-268.8 – 369.6	Automotive felt, thermal insulation, shoddy, briquettes for industrial heating	Where end market applications have been found, recyclers report reasonable revenue, though many recyclers reported sending the material to landfill or EfW, as no outlet was available to them. Much is dependant on quality of material and separation from other components of the mattress.
Polyester	£100-160	560	5.6 – 89.6	Polyester products/ fabric	Polyester only has value when separated from other materials – where it arises in flocking it is considered a 'mixed textile'.
Wood		Exact tonnage not clear[129]		Wood mulch, MDF or fuel	
Coir (& other natural materials e.g. hemp and horsehair)	£0-30	980	0 – 29.4	Compost, fuel	Coir is collected in relatively small volumes, and several recyclers iterated small, niche uses for it (one recycler used it for a home wood fire, and a Canadian recycler gives it away at their depot for use in the garden).
Total		**14,000**	**371 – 1,878.8**		

Source: Confidential recycler inputs, WRAP Materials pricing report

[128] £520 per tonne is significantly higher than any recycler spoken to was receiving for PU from mattresses, so 100-130 is considered a more realistic range

[129] Wood collected is typically combined with bed bases – typical mattress composition no longer includes wooden frame

6 Barriers to mattress recycling and material markets

There are several barriers to end markets for mattress recyclers, particularly for the textile proportion. Listed below are some of the key issues associated with poor return on materials:

Table 6.1 Barriers to end markets for mattress materials

Barrier	Cause	Intervention opportunity
Difficulty in uptake by local authorities	Cost of landfill low (may cost local authority less to landfill than recycle)	Maximising return income through high quality end materials, and offering convenience of collection may encourage uptake. Highlight potential maintenance costs of landfill vehicles which may be damaged by mattresses. Potential outside intervention from waste policy, landfill bans, or specific gate fees for mattresses (and bulky furniture) at landfill.
Cost of set up	Expensive equipment if automated	A simple set up for manual deconstruction has relatively low investment; most high costs are associated with equipment not necessarily required, such as conveyors and shredders. Further capital outlay is possible after return has been seen.
Lack of mattress supply	Poor awareness	This was not highlighted as an issue in the UK, though was mentioned by two American reprocessors, and therefore mentioned here as a consideration for new operators. Ensuring local authorities and commercial users (e.g. hotel chains) are contacted and made aware of the opportunity should encourage uptake, with ample available mattresses (being sent to landfill).
Quality of material	Damp/dirty mattress	Minimise outside storage (both at point of collection by user, and at storage site once collected).
	Poor deconstruction	Avoid shredder use.
		Maximise level of separation of material.
	Poor understanding of required quality	Ensure end distribution routes are established before deconstruction begins, to agree quality thresholds and material standards.
Saturated UK textile market	Competition from clothing rags limits market for textile. Need to overcome poor perception of post-consumer material	Ensure high quality output to achieve links with higher value end applications. Development of end markets required – particularly within the UK. Need solution to wash contaminated textiles?
Low value return on material	Springs receive lower value than compacted steel	Invest/develop compactor where possible.
	Textile return weak	Ensure high quality output to achieve links with higher value end applications such as automotive felt, insulation and potentially pet bedding etc. Development of end markets required. Produce own end products for direct sale to consumers – taking control in-house and reducing outside market fluctuations.

6.1 Summary

The mattress recycling sector in the UK is relatively immature, though recent years have seen substantial growth in the number of initiatives arising. Success rates are still varied, with the key barriers appearing to be the relatively low cost of disposal to landfill (requiring the recycling of mattresses to be cost-effective in comparison) and limited end markets for some materials (restricting the revenue available). These two factors combined create a difficult economic environment, in which the feasibility of any mattress recycling project is determined by the ability of the reprocessor to capture high value end markets. These are known to exist but, due to the highly competitive nature of the sector, are not widely discussed and therefore not easily accessible.

Development of these end markets - in areas such as automotive felts, insulation and padding for pet bedding (the latter unlikely to accept high volumes), but also in novel applications - would be beneficial to increase profitability of recyclers. Further support and funding to research organisations and academics in this field would be recommended. The development of cost-effective spring compaction equipment would also have a significant benefit to the sector, as the difference in value of available steel is over £600,000 in Scotland, due to more efficient transportation.

Encouraging retailer and manufacturer participation is also recommended, with costs more easily passed on to customers for take-back service charge. The use of delivery vehicles to back-haul old mattresses would also be beneficial, as it would obviate the need for additional transport to remove the collected mattresses, and prevent the likelihood of leaving mattresses standing in unprotected areas, potentially resulting in wet or dirty items (reducing their recyclability). Reselling whole mattresses when unused (retailer rejects/customer returns) is also profitable, and re-use maintains a higher 'environmental benefit' according to the waste hierarchy.

Whilst the sector is highly competitive (and recyclers are cautious regarding end market demand for recyclates), there is a huge volume of feedstock available to grow the sector. Typically operations are relatively small; many of the smallest - often charitable - organisations are not discussed in depth within the remit of this report. Of the more substantial operations investigated, 11 of the 15 sites handled fewer than 2,000 tonnes of mattresses, with six of these handling less than half of this volume. This fragmentation in itself can create barriers to end markets, as end users prefer materials to be supplied in larger volumes.

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