OAKDENE HOLLINS

Appendix I

Maximising Reuse and Recycling of UK Clothing and Textiles EV0421

Technical Report

Final report

for

Defra

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Glossary

ACS	Association of Charity Shops
BATC	British Apparel and Textile Confederation
BFA	British Footwear Association
BIR	Bureau of International Recycling
BMW	Biological Municipal Waste
CA	Competent Authority
CAT	Charities Advisory Trust
C & I	Commercial and Industrial
CRR	Centre for Remanufacturing and Reuse
CSR	Corporate Social Responsibility
Defra	Department for the Environment, Food and Rural Affairs
DCSF	Department for Children, Schools and Families
DMT	Dimethyl terephthalate
ECJ	European Court of Justice
EfW	Energy from Waste
EoL	End of (First) Life
EU	European Union
HWRC	Household Waste Recycling Centre
IL	Ionic Liquids
LATS	Landfill Allowance Trading Scheme
LA	Local Authority
LARAC	Local Authority Recycling Advisory Committee
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
NIEA	Northern Ireland Environment Agency
NIRI	Nonwovens Innovation & Research Institute Ltd
NMMO	N-methyl-morpholine-N-oxide
OU	Open University
PPE	Personal Protective Equipment
SATCoL	Salvation Army Trading Company Limited
SBR	Styrene-butadiene latex rubber
SEPA	Scottish Environment Protection Agency
TFS	Transfrontier Shipment
TRA	Textile Recycling Association
TRAID	Textile Recycling for Aid and International Development
WCA	Waste Collection Authority
WDA	Waste Disposal Authority
WFD	Waste Framework Directive
WRAP	Waste and Resources Action Programme

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- Salvation Army Trading Company Ltd, TRAID, ClothesAid, Bag2School and other non-TRA recycling organisations.
- All other members of the stakeholder steering group, as listed in Appendix 3.

1 Introduction

1.1 Background

This project is one of three projects commissioned by Defra as part of the Sustainable Clothing Roadmap[1]. Studies on the environmental impact of products, notably the EIPRO[2] report, identify clothing as having a significant environmental impact over its lifecycle. Maximising reuse and recycling of clothing helps to reduce this impact.

Previous studies on UK clothing reuse and recycling[3][4] have indicated that this is relatively low (between 14% and 22% of MSW). In addition the percentage of textiles discarded as part of household waste has been forecast to rise more rapidly than other products or materials, albeit from a modest base[5]. These factors have led to consideration of policies such as extended producer responsibility on clothing[6][7].

1.2 Scope and definitions

This project considers the end of a product's first life (EoL), with a scope that includes domestic and commercial textiles such as carpets, corporatewear and textile rental products, as well as domestic clothing. Its scope includes closed loop recycling of textiles, but not textiles made from non-textile recyclates such as plastic bottles. Nor does it include post-industrial scrap such as garment cuttings, but only textiles discarded after use.

Textiles in this study are defined to comprise common consumer textiles such as clothing, carpet, bed linen, towels, whether they are provided via a corporate organisation (e.g. NHS uniforms) or purchased by the end consumer. *Reuse* of textiles is defined as the original **product** function (e.g. clothing reused as clothing to cover a body), whereas *recycling* is use of the

[1] See http://www.defra.gov.uk/environment/business/products/roadmaps/clothing.htm
[2] "Environmental Impact of Products" Institute for Prospective Technological Studies, European Commission May 2006
[3] "Well Dressed?" Cambridge University, 2006
[4] "Recycling of Low Grade Clothing Waste" Oakdene Hollins Ltd, Salvation Army Trading Co. Ltd., Nonwoven Research Institute, Defra WS Project WRT152, 2006
[5] "Modelling the Impact of Lifestyle Changes on Household Waste Arisings" Maunder A. et al. Paper presented at Waste 06, Stratford upon Avon, September 2006
[6] "Clothing Recycling and Producer Responsibility" Morley, N. et al. Paper presented at Waste 06, Stratford upon Avon, September 2006
[7] Geffroy, V. "Cas des déchets textiles des ménages en France : La responsabilité élargie des producteurs" Paper presented at Conférence Internationale "Responsabilité des producteurs"

clothing **material** properties (e.g. absorbancy in a wiper; as a fire retardant nonwoven in a mattress spring cover). Recycled textiles can be **upcycled** into higher value or more technically demanding applications, or **downcycled** into less demanding, lower value applications. Such applications include **shoddy**, fabric made from the recycling of knitted products; **mungo**, fabric made from the recycling of woven products of consequently lower fibre length; and **cotton rag paper** made from recycled cellulosic fabrics.

1.3 Aims and objectives

The overall aim of this project is to report up-to-date, comprehensive and robust data on the quality and quantity of clothing and textiles waste in the UK and to present and evaluate strategies for increasing reuse and recycling rates. This includes a detailed assessment of:

- Barriers and enablers to maximising reuse and recycling
- Technical feasibility of options
- Infrastructure requirements
- Examples of Best Practice from overseas.

Detailed recommendations for maximising the recycling and reuse of clothing and textiles waste generated in the UK are made, specifically addressing the role of a variety of stakeholders in any interventions (voluntary or mandatory).

2 Methodology

The project is comprised of a desk- and interview-based study with some empirical work related to quality of clothing. It will follow on from the previous report by Oakdene Hollins on the recycling of low grade clothing waste (Defra WS Project WRT152). We also draw upon data and information that has been gathered for the project on corporatewear reuse being carried out by the Centre for Remanufacturing and Reuse, which is operated by Oakdene Hollins.

A literature/data review and survey of key stakeholders was carried out to clarify the information gathered and identify key themes. Quantities of clothing and textiles collected for recycling and disposed of in the household waste stream were estimated using a variety of sources including surveys by the Association of Charity Shops, industry estimates by key participants, and previous research on waste management statistics. In addition M·E·L Research were contracted to identify the quality of the textile waste stream disposed of in household waste and its suitability for reuse and recycling – an evidence gap that was identified in the 2006 study. This was done not only by interrogation of M·E·L's previous survey work on waste composition, but also by a sorting trial in Birmingham using textile recycling and reuse grades to categorise textiles from residual household waste.

Information was obtained from a number of sources including:

- Internet searches - i.e. business, academic, UK and overseas trade and industry association websites.
- Literature searches - i.e. trade and academic journals, company literature, 'grey' literature and datasets.
- Clothing Roadmap stakeholders. Their input and feedback formed an important part of this study and was obtained partly through a stakeholder workshop held to present the interim results of the research.
- Other key stakeholders who are not directly involved in the Defra Clothing Roadmap where appropriate (e.g. Carpet Recycling UK, Reeds Recycling, Spruce Carpet Tiles, etc.).
- Site visits such as to IG Cohen, Wilcox Textile Recycling.

The robustness of the evidence gathered was assessed in terms of credibility, reliability and objectivity. Once collated, the information (qualitative and quantitative) was analysed to form the basis for the development of a series of key recommendations, devised by Oakdene Hollins and circulated among Clothing Roadmap stakeholders for comment and review and then included in the final report.

3 Legislation and Policy

3.1 National

The relevant legislation affecting the secondary textiles industry has changed very little in recent years; a summary of the major regulations is listed in Table 3.1 and Table 3.2.

Table 3.1: Summary of Legislation affecting the Secondary Textiles Industry

Legislation	Information
Environmental Protection Act (1990), Part II	Waste textiles considered as 'controlled waste'. Specifies collection, disposal and treatment of controlled wastes.
Waste Minimisation Act (1998)	Powers to WDAs and WCAs to minimise the generation of controlled wastes.
EC Council Regulation (EEC/259/93) Supervision and Control of Transfrontier Shipments of Waste	Regulates the shipping abroad of used textiles.
Controlled Waste Regulations 1992	
Landfill (England and Wales) Regulations 2002	Imposed controls on inputs to landfill sites, specifically targets for diversion of biodegradable wastes from landfill.
Pollution Prevention and Control (England and Wales) Regulations 2000	This has now been streamlined into Environmental Permitting (England and Wales) Regulations 2007 (SI 2007 No 3538)

Table 3.2: Other Regulatory Measures affecting the Secondary Textiles Industry

Measure	Information
Landfill Tax Escalator	Currently (2008/2009) £32 per tonne, and increasing to £40 per tonne in April 2009.
Waste Framework Directive	Currently 2006/12/EC in force, however, as of 12th December 2010, Directive 2008/98/EC to be fully implemented
Landfill Allowance Trading Scheme	Financial incentive to WDAs to reduce landfilling. Recycling/reuse credits to collectors and re-processors.
Waste Incineration Directive	

3.2 Definition of waste

The definition of waste in force in the UK is the definition in Article 1(1)(a) of the Waste Framework Directive (WFD) (2006/12/EC) and it provides that:

"'waste' shall mean any substance or object...which the holder discards or intends or is required to discard."

The WFD is an EU-wide directive, with each Member State responsible for translation into national law. In the case of the UK, Defra is responsible. Whether any particular substance falls within the scope of this definition is something that must be determined on the facts of each case, and the interpretation of the law by the Courts. There is now a substantial body of Case Law by the European Court of Justice on the interpretation of the WFD's definition of waste and the meaning of "discard". The definition of waste as regards the textiles disposal stream is complex.

The issue arises as to when donations of clothing and textiles qualify as waste. Materials received from door-to-door collections and those deposited at charity shops are deemed as non-waste, as the perception is that they are donated with the intention of reuse, as well as being of high quality and suitable for wear or reuse. Materials leaving charity shops, however, are expected to contain items too soiled or damaged to be suitable for reuse. These are classified as waste until sorting has occurred.

Collections from textile banks are frequently incorrectly perceived by industry to be classified as waste, as they are expected to contain unsuitable (e.g. soiled) material, or deposits of unwanted foreign objects. Interviews with industry members have highlighted confusion and uncertainty surrounding the matter. The Environment Agency, however, iterates that banks collecting 'quality' textiles are regarded as containing largely reusable items, and therefore do not fall under the definition of waste.

The Environment Agency[8] has given advice on the issue, thus:

Second hand clothes are deemed to be 'useable', and therefore not a waste, providing they are:

i. suitable for continued use as clothes; and
ii. being exported for sale and/or use as clothes.

The Environment Agency's view is that textiles that are collected as second-hand goods for continued use for their original purpose are not waste. This could include

[8] Personal communication, Alan Owers, Environment Agency, 2009

donations to charity shops, door to door collections and textiles placed in banks for this purpose.

According to Defra[9], several years ago the European Commission requested Member States' views on a draft information sheet (i.e. guidance) on the classification as waste of used clothes. The response from the UK included the following extracts:

"*After consultation with representatives of the organisations which are mainly responsible for the collection of used clothes in the UK, the response was that these organisations operate the collection banks on the basis that used clothes are put in the banks with the intention that they should continue to be used for their originally intended purpose as clothes; and that the intention of those making the donations is that the clothes should either be sold as clothes or given for use as clothes to people who need them. These intentions are confirmed by the proportion of clothes which after sorting is sent by the collecting organisations for continued use as clothes and the proportion which is disposed of as waste. Defra were advised that after sorting only about 7% of the contents of collection banks for used clothes are disposed of as waste in the UK; and that a significant proportion of this 7% comprises the plastic bags and other containers in which the used clothes were put in the collection banks.*

On the basis of this information, and taking account of the judgments on the definition of waste in cases considered by the ECJ, it is the UK's view was that when used clothes are put in a collection bank with the intention that they should continue to be used for their originally intended purpose as clothes then they have not been discarded as waste within the terms of the definition in Article 1(1)(a) of the Directive."

In consultation with stakeholders elsewhere in the industry, this 7% is believed to refer to 'true' waste, i.e. the proportion sent to landfill not sent for recycling. If the recycling proportion is also considered (officially classed as waste until processed into a useful product), a higher percentage is considered to be present. Clothing exported for use as wipers or fibre recovery is classified as a waste, and carriers must abide by the TFS Regulations (see section below). However, if exported for sale as clothing, waste regulations should not apply and therefore textile bank collections are not listed as waste and are considered exempt from waste regulations. Whilst the findings of this report concur with 7% only of textile bank collection material going to landfill, it has been stressed by members of the UK sorting industry that this overlooks the ca. 30-40% of textile bank contents that are not suitable for reuse, but only for recovery via recycling. The definition of waste in regard to textile banks therefore does still lead to confusion among industry members. The key issue appears to be whether the textiles are donated in the belief that they are to be reused.

[9] Personal communication, John MacIntyre, Defra, 2009

The subject is further confused due to disagreement between the environmental bodies of different countries. The EA has a contrasting view to SEPA and NIEA on the issue: the latter two classify textile bank materials as a waste, causing problems within the UK alone.

It is important to note also that the WFD has recently been revised, with a new Directive (2008/98/EC) adopted in December 2008. The revisions will not, however, become transposed and implemented until December 2010. The revised WFD does not alter the definition of waste, but does include a range of measures to give greater emphasis on prevention of waste and maximising the reuse and recycling of waste that is created.

There is some potential contention with this issue from other sectors, as operators of other recyclate banks may feel justified in asking for classification as non-waste. These recyclate banks are not seen as comparable however, as it is only textile banks that reuse the majority of product 'as is', rather than break down the material for recycling.

3.3 Transfrontier shipment regulations

The Transfrontier Shipment of Waste (TFS) regulations control the export of waste though clothes in a reusable state are exempt. Increasingly, textiles - such as clothing - are exported out of the UK for reuse in developing countries such as the African nations, as well as countries within the Middle East and Eastern Europe.

A major concern of textile recyclers who carry out sorting in the UK is the export of unsorted clothes from charity shops and textile banks to countries such as Poland for sorting into reusable/recyclable and waste categories. It is argued that unsorted clothing should be subject to the TFS regulations, but often avoids them. There is a perception among some UK sorters that much of the textiles exported in this manner ends up in landfill if not 'wearable'. However, no specific evidence has been presented or has been locatable by the researchers so these claims remain unsubstantiated. There are also counter claims from exporters of unsorted clothing of very high recycling and reuse rates overseas. As there is value in fibre reclamation, we believe that it is likely that these unwearable clothes and textiles are likely to go for further processing.

If classified as waste, textiles are a Green List waste, meaning that they can be sent to the majority of EU member states and to OECD countries under Green List controls. Export to non-OECD countries, such as in Africa, is more complicated and requires written forewarning of wastes, asking for indication of controls the receiving country would like imposed on the imports. If not classed as waste, these conditions do not apply.

The issue is further complicated by international regulations. Textiles appear on the European Waste List, and it is up to the Competent Authorities in each of the countries of the EU to decide when textiles are, or are not, waste. Therefore, clothing and textiles exported out of the UK legally may be deemed waste by another Competent Authority, leading to legal complications and possible impounding of goods. This is highlighted when considering the UK alone, where English and Scottish Environmental bodies disagree on the exact definitions.

Revision of the Waste Framework Directive, however, is expected to include textiles on the priority list of wastes for consideration under the 'End of Waste Mechanism', meaning an EU-wide definition may be forthcoming within the following two years[10]. The Bureau of International Recycling[11] iterates that the European Commission is due, in the near future, to start defining the exact criteria for when a 'waste' becomes such and when it is still a 'product'. The beginnings of these findings are expected within the year, with textiles alongside other materials and products such as metals, tyres and glass. This should significantly reduce the current confusion.

3.4 Door-to-door collections

The Charity Commission is the body responsible for registering charities. If these registered bodies then wish to operate door-to-door collections of textiles, they must request a licence from each individual Local Authority (or in the case of London, the police) to collect in a particular area. Organisations operating on a nationwide scale on regular occasions are able to apply for a National Exemption Order from the Office of the Third Sector, meaning they are still bound by the same regulations, but do not have to apply in each authority district for each collection. Entirely commercial organisations wishing to collect textile donations in this manner, are not, however, bound by these regulations. However those acting in partnership with a charity (typically using the charity name/branding on bags and leaflets, and then paying the charity a price per tonne collected), are required to comply with charity legislation.

The Charities Act is currently under review, and the regulation of these collections is potentially due to change. In a discussion with the Commission[12] regarding the change in the Act, it was suggested that the regulations are not likely to be adjusted substantially, with the only potential alteration being the removal of responsibility from the Local Authorities and

[10] Personal correspondence Alan Wheeler, Textile Recycling Association, Dec 2008

[11] BIR Annual Report, 2008

[12] Personal communication with Steven Mann at Charity Commission, Feb 2009

police. Current investigations are being carried out by the Office of the Third Sector assessing the resource implications of such a move.

One probable reason for this potential change of position is the occurrence of 'bogus' collectors (organisations misrepresenting themselves, for example as charitable when they are not) and theft, which is causing a significant issue for registered collectors. A recent study by industry members[13] suggests 14-20,000 tonnes of textiles were collected by unregistered organisations in 2008. Collection by commercial, unregistered organisations is permissible, but such organisations often try to appear 'charitable' and are thus regarded by charities as 'bogus' collectors. Industry estimates up to £3 million lost to charities each year due to this issue[14] and high frequency of 'bogus' collections (particularly in certain 'hotspot' areas) is perceived to reduce the inclination to donate textiles by households. Whilst there is some evidence that the public are generally better aware of how to recognise 'bogus' companies, largely through educational campaigns by organisations such as the Association of Charity Shops and ClothesAid, there may be a perception of 'donor fatigue'. A reduction in collection tonnage via this method may make it increasingly difficult for authorised organisations to continue in a sustainable manner; however no evidence was presented or was located to substantiate this claim.

According to the Cabinet Office (Office of the Third Sector)[15], the aim of the new legislation is promotion of stronger self-regulation by industry. It is not felt that resources available to the Office are going to be sufficient to police the entire country, particularly in regards to theft of collections, as this falls under the bounds of criminal law, if, for example, one charity's bags are collected by another collector. Details are still being evaluated, however, with frequency of collections being one area of investigation. Results of the research are not due until December 2009.

Our own contacts with local licensing authorities indicate very few instances of refusal. There appears to be little or no enforcement of regulations and the current management of frequency of collections in particular areas appears variable. The possible alterations to the Charities Act help regulate the situation, but only if the power to enforce is increased, which is unlikely. Removal of Local Authority responsibility is also unlikely to come into effect until 2010-11, and the amendments do not resolve the issue of regulation of non-charity organisations. The use of an industry-wide standard for collectors (charities, partnerships and purely commercial), such as a stamp of certification, may be a good way of controlling collections, though agreement as to what this should cover may be contended by different industry

[13] Study carried out by ClothesAid, 2008
[14] Association of Charity Shops and ClothesAid survey 2007
[15] Personal communication with Mubin Jaigirdar, Cabinet Office, April 2009

members. The use of a recognisable stamp on collection vehicles, may also allow the public greater opportunity to report thefts, which are often not noticed by the public. Charities with shops already have a code of good practice for collections - the Code of Charity Retailing. This has been in force for nearly a decade and is a mandatory requirement for members of the Association of Charity Shops (ACS). A similar, but more widely incorporating, code is recommended for a greater standardisation across the whole industry. Such a code should, for example, clearly state whether there is any charitable gain from collections, and if so how much. This would be most successful if marketed well and the general public are made fully aware of the details of such a scheme.

The ACS have also drawn up a wider collection code for charities that do not run shops, but wish to benefit from collections operated by a commercial partner. This is in a stage of consideration by the legal team and at Board level. This may go some way towards resolving a number of the issues, but a code covering non-charity collections also is still recommended.

Another potential method to reduce theft of bags, suggested by some industry stakeholders themselves, is to organise an industry-driven policing service. Whilst this may be costly, if a number of industry members teamed together to provide this sort of set up, then any organisations caught taking textile bags that did not belong to them could be arrested with the textiles reclaimed to the rightful collector. The savings made from prevented loss can be put towards the policing system, with the ultimate ideal being the organisations becoming to wary of arrest to carry the risk of stealing.

Whilst this sort of system may work on a small scale, it seems unlikely to be able to run on a nationwide, on-going basis, without the total cost negating any prevented losses made.

3.5 Local Authorities

Local Authorities have specific targets set for reduction of household waste to landfill, through the Landfill Regulations. Targets for biodegradable waste in particular are driving the increase of kerbside textile collections, as 50% of used textiles are regarded as biodegradable. As textiles can often be a challenging material to collect (co-mingled collections can cause soiling, and reduce reuse/recycling potential for example), Local Authorities often involve external organisations to aid collection.

3.5.1 Third party credits

Local Authorities can opt to pay third party organisations credits for diversion of materials from landfill, in the form of either recycling or reuse

credits. (The option of reuse was introduced in 2006, to attempt to incentivise this 'higher' waste hierarchy recovery route.) The payment of either of these is voluntary, however, so utilisation around the nation is irregular. A questionnaire sent to all Local Authorities in 2006 gave a result of 49% of respondents paying credits for textiles, though this was felt to over-represent the true picture as those Local Authorities paying credits were felt to be more likely to respond.

Reuse credits do not appear to be a great incentive for textiles, and a small survey of Local Authorities known to offer reuse credits found only a single Authority that paid these for textiles - and this was only as a combination with furniture. The average price paid was £47.71, with a range of £44.16-52. The use of credits is not a strong motivation given the high current price for textiles. However it may be more important in the future if textile recycling becomes economically more marginal.

3.6 Recommendations

The legislation in place affecting the secondary markets and collection of textiles has changed very little since the previous report. However, the issues raised in 2006 do not seem to have been resolved adequately, with the main problems occurring around the clarity and enforcement of regulations involved. Specific recommendations are as follows:

- Greater clarity is needed on waste definitions, particularly in regard to textile banks. Where the content is reusable, this is not defined as a waste and as such is exempt from waste regulations, and this should be more clearly disseminated to industry members. However, clothing which is exported unsorted should become more traceable, with recycling and reuse rates published by individual recyclers or industry bodies, in order to ensure responsible recovery methods are being carried out.

- The TFS Regulations require stronger enforcement. Where textiles are deemed as waste, regulations need to be adhered to. This will discourage inappropriate export of unsorted garments, and will both stimulate UK sorting, and may reduce the occurrence of unregulated collections.

- Current high prices and demand have provided a stronger incentive for collection than Local Authority credits, and no recommendation is given for greater investment in this system at the present time. However, it is important to note: should current prices drop, this situation may be reversed.

- Increased communication between charities, legitimate commercial collectors and public authorities in regards to identification of 'bogus' collections, and proper enforcement actions once these organisations have been recognised.

- Development of a universal code of practice - with regard to door-to-door collections, to regulate frequency and, if marketed well, to enable the public to better both recognise and report 'bogus' collectors and thefts. This needs to incorporate both charitable and commercial sectors.

- Removal of the licensing of door-to-door charitable collectors from Local Authority control.

- Focus on Trading Standards as the most appropriate enforcement authority for 'bogus' collectors.

4 Material Flow

The different collection mechanisms are discussed in depth in Section 5. These, along with some of the tonnages processed, can be seen represented in the map in Figure 4.1 overleaf. Commercial and exhibition carpet is not included in the process map, because it enters the non-municipal waste stream, and also as the recovery opportunities available vary to some degree. See Section 6.2.5 for a greater discussion of EoL options for carpet.

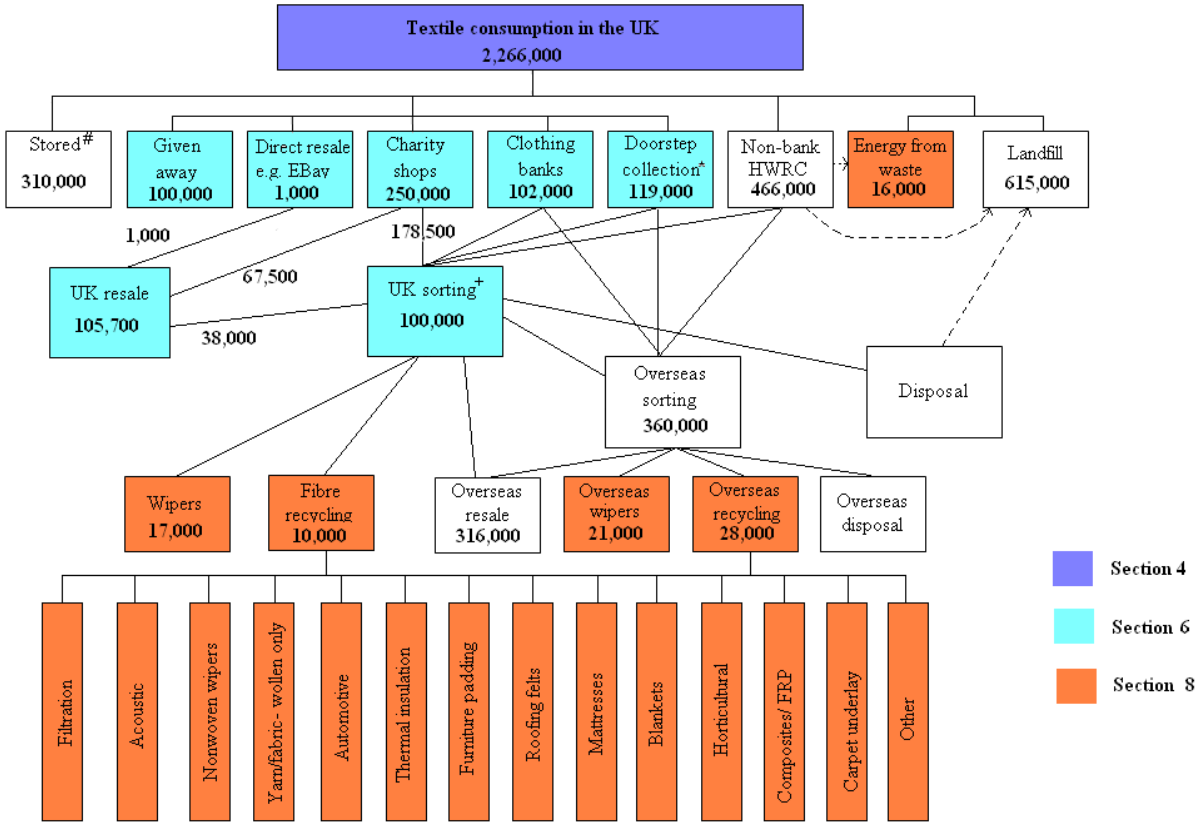
The evaluation of tonnage of textiles consumed in the UK was challenging. Previous reports have been able to use data supplied by the British Apparel and Textile Confederation (BATC), and the Office of National Statistics (ONS) to determine unit number and values for all categories. According to the ONS[16], an increasing percentage of UK manufacturers have opted to 'suppress' certain figures due to commercial sensitivity, as manufacture moves overseas. This has resulted in some data gaps in individual textile categories.

Most collected textiles go towards reuse, either in the UK or abroad. The typical collection option has a number of secondary markets available to it, be they direct use themselves (e.g. charity shops reselling locally), sale to textile reprocessors in the UK, or export to be sorted and distributed overseas. Little is known about the final destination of exported goods, and therefore the tonnage to resale (316,000 tonnes) is likely to actually be lower, with some material unsuitable for wear, and some too badly soiled or damaged for any recovery and ultimately ending up in landfill. The proportion of recovered material is highly contended, with some industry members believing it to be lower than in the UK – resulting in a significant quantity of textiles to foreign landfill. However, it is more likely that, due to the inherent value of textiles and the infrastructures known to be available in a number of the more popular export countries, any unusable items are likely to be reclaimed if possible.

Not all pathways had enough available data to provide breakdown of figures, but those that did have been included. The figure for UK sorting is difficult to quantify, as most textiles collected have some very marginal sort process, even if just to remove bulky foreign matter. Even if sorted in the UK, a significant proportion is exported, to be sorted further. The figure of 100,000 tonnes is an approximation of the more in-depth sort that results in textile grades being segregated.

[16] Personal communication with Nicola Smith of ProdCom, 2009

Figure 4.1: Pathways of end-of-service clothing in the UK (all data in tonnes)



*Including LA collections

+This figure varies largely depending on the definition of sorting used

#National wardrobe, including stored and not in use

4.1 Consumption

4.1.1 Apparel

Figures on volumes of apparel produced in the UK in recent years have been very difficult to come by, with data available by value only. Sales values of new products for 2006 according to the BATC, are shown in Table 4.1.

Table 4.1: Consumption of new apparel in the UK, in 2006

	Sales by Value (£m)
Apparel production in UK	3,871
Total imports	12,077
Total exports	2,859
Total consumption	13,089

4.1.2 Household textiles

Consumption of household textiles in the UK is shown in Table 4.2. This includes bed linens, blankets, towels etc, but does not include carpets which are covered in Section 4.1.3.

Table 4.2: Consumption of new textiles in the UK, in 2007

	Consumption ('000 tonnes)
Blankets	28.5
Bed linen	73.8
Table linen	5.8
Toilet/kitchen linen (incl. towels)	44.5
Bedding articles	50.8
Soft furnishings (incl. cushion covers)	14.2
Sleeping bags	5.4
Cloths/dusters etc	14.4
Other	27.5
Total	**265**

4.1.3 Carpet

186 million metres of domestic carpet were sold in 2007 in the UK[17]. The average domestic carpet mass is 2kg/m^2, giving a total of 372,000 tonnes consumed by households.

Total consumption of carpet in the UK for 2007 was 570,000 tonnes[18], commercial and event carpet use is therefore taken to be 200,000 tonnes. Details of carpet consumed are given in Table 4.3 below.

Table 4.3: Carpet consumed in UK, in 2007

Carpet type	Area ('000 m^2)	Tonnage ('000)
Woven	10,500	23.4
Non woven	246,300	546.7
Total	**256,800**	**570.1**

4.1.4 Other arisings

Whilst footwear is not officially included within this study, textile collections often include these in total tonnage, and therefore arisings are noted for reference. It is also listed for comparability with the previous (2006) report. The British Footwear Association[19] reported sales for 2008 at £6 billion. At an average price of £20 per pair, a total of around 300 million pairs were sold. The average mass of a pair of footwear is 500g, bringing a total of 150,000 tonnes of footwear entering the market (an 11% decrease from the 2006 figure of 169,000 tonnes). The industry estimate is that only 5% of these are recovered at end-of-life.

Mattress sales in the UK in 2007 had a value of £522.7m, or approximately 7.5m individual units sold. This equates to over 160,000 tonnes of mattress material sold, comprised of metal, wood and textiles, in both the covering fabric and foam or soft fabric stuffing.

Healthcare – The mass balance work carried out for the NHS in 2004[20] gives textile consumption as 36,400t. This includes uniforms, bedding, towels, blankets and other textile products. This is not included as an additional arising, however, as it is believed that these items are accounted for

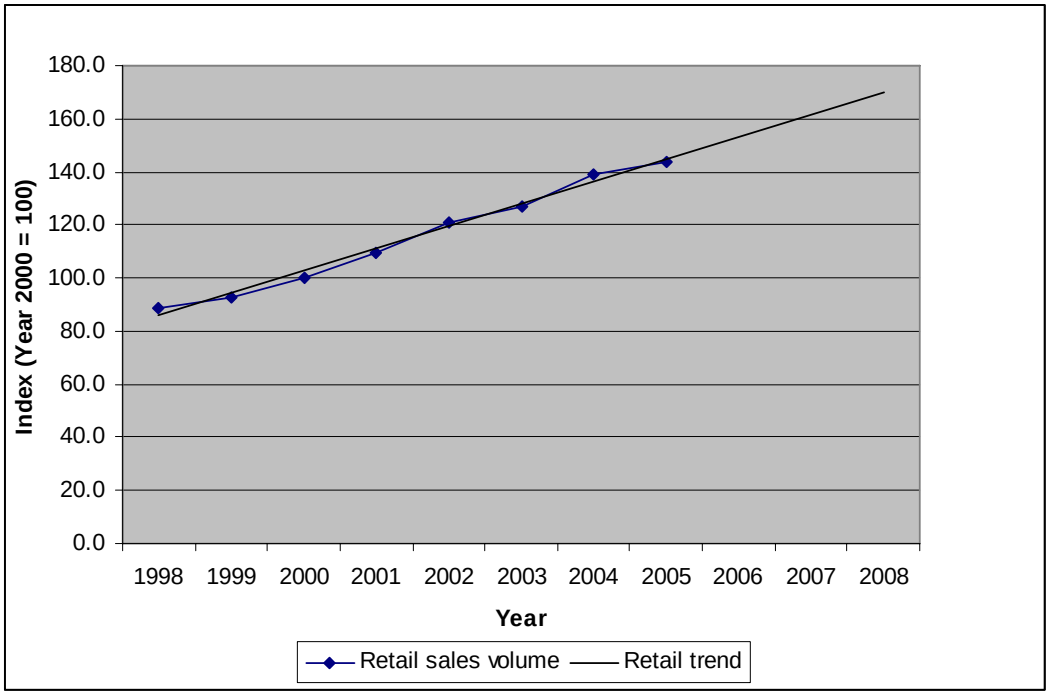
[17] Carpet Recycling UK data, 2008
[18] ONS data, 2007
[19] Personal communication, Richard Kottler, 2009
[20] Material Health, Best Foot Forward ltd, 2004

elsewhere. It was felt useful to include, however, as it gives an indication of areas where the textiles are being used.

4.1.5 Sales index

Using historic BATC data, the growth in volume of new clothing and textile sales in the UK is displayed in Figure 4.2. Although the data are only available until 2005, the trend line is extrapolated to present an estimate of sales volume in the UK for 2007 of 2.04 million tonnes. This is a maximum tonnage, as the recent crisis affecting the global economy may have had an impact on sales, though most effects of this are believed to have occurred during 2008 onwards. Sales value has been steadily decreasing over a number of years, as imports and value retailers offer garments at low prices.

Figure 4.2: Growth in new clothing and textile sales in the UK



Using this figure of 2.04 million tonnes, and the arisings in other areas, it is possible to determine the approximate sales of clothing in 2007. Table 4.4 shows the breakdown of textile consumption in 2007. The clothing figure was determined using the total given in Figure 4.2 and subtracting figures in other areas. The split between men's and women's sales is presumed to be the same as in the previous report. Only domestic carpet figures are included for the BATC index used, but commercial arisings are included below.

Table 4.4: Apparent UK consumption of new textiles and footwear, 2007

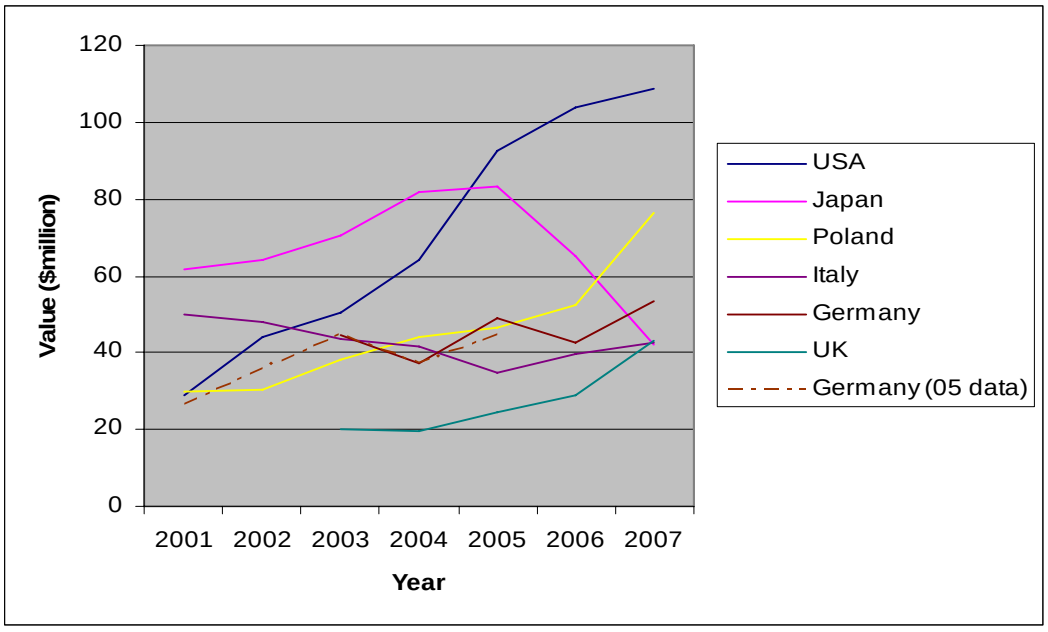
Textile	Consumption ('000 tonnes)
Men's clothing	538
Women's clothing	713
Household fabrics	265
Domestic carpet	370
Footwear	150
Subtotal	**2,036**
Commercial and event carpets	200
Total	**2,236**

Total clothing sales are seen to be 1.25 million tonnes, an increase of 70,000 tonnes from the 2003 data.

4.2 International trade in worn textiles

Trade in worn textiles by value has seen a marked increase across most of the globe, with both imports and exports increasing for many countries. Almost all countries reviewed showed an increase, with Japan being one of the few that displayed a substantial decrease. This is likely to be due in part to the value of worn textiles, consumer behaviour and the movement of manufacture away from traditional geographic sources.

Figure 4.3: Annual imports of worn clothing and other worn textiles per year, by country



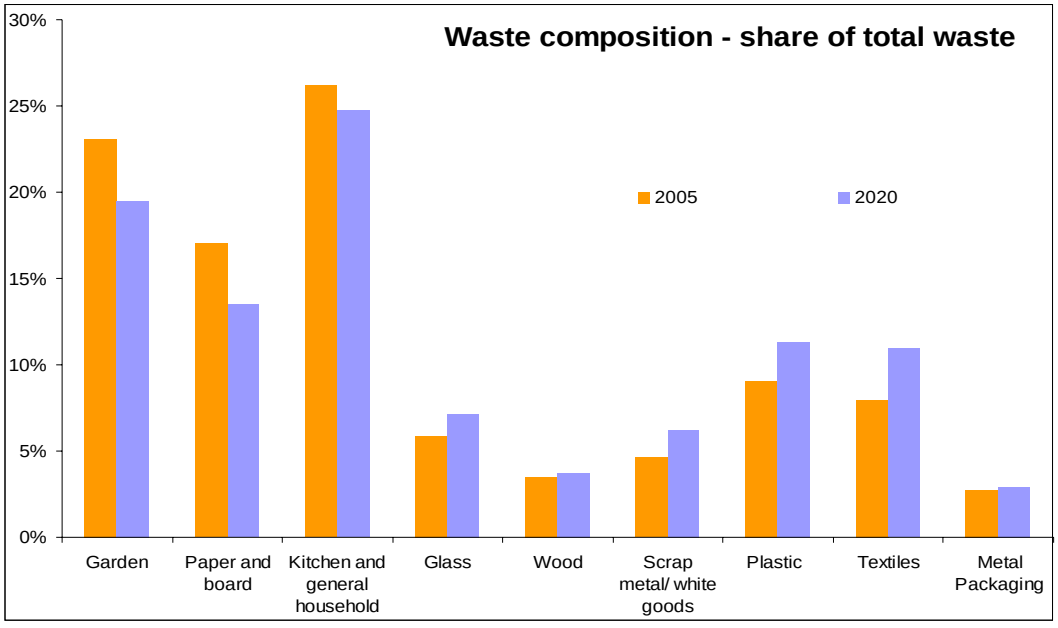
The UK has more than doubled the value of intake of worn textiles since 2003, from $20m to $43.3m in 2007. The more sizeable export of used textiles also increased, climbing from $176.4m in 2003 to $360.5m in 2007, though data is given in $, resulting in currency fluctuation (see Section 6.7.2). These trends are partly due to general increases in global trade flows caused by the opening up of formerly closed markets such as Eastern Europe, and partly caused by the specific movement of textiles sorting into overseas markets and the consequent re-import of certain textile categories.

4.3 Textiles entering the waste stream

4.3.1 Household textiles

The consumption and disposal rate of clothing and textiles has increased dramatically in recent years, particularly driven by the advent of 'fast' or 'discount' fashion[21][22]. In fact, the total share of clothing and textiles waste is forecast to be the fastest growing household waste stream from 2005 to 2020, as illustrated in Figure 4.4.

Figure 4.4: Household waste composition, by waste category, 2005 and 2020



Source: Maunder et al (2006) Modelling the impact of lifestyle changes on household waste arisings.

[21] 2006 Biffaward Project "Well Dressed" University of Cambridge,

[22] Mapping of Evidence on Sustainable Development Impacts that Occur in the Life Cycles of Clothing" ERM for Defra

In a survey of over 1000 streets, across ten years, M·E·L Research studied the composition of waste disposed of by households. Table 4.5 shows the average proportion of textiles in the household waste stream. This shows that the percentage of textiles has been increasing, but at a lesser extent than the decrease of total waste. This is likely to be due to increased recycling rates across other sectors reducing the quantity that households throw out, yet, whilst textile recycling has been increasing, it is at a slower rate than these other materials. The full M·E·L report can be found in Appendix 1.

Table 4.5: Textile contribution to household waste since 2000.

Year	Total Waste (Kg/hh/week)	Textile Percentage
1999	12.57	2.83%
2000	14.98	3.34%
2001	13.87	3.61%
2002	16.37	3.63%
2003	14.04	4.14%
2004	11.22	3.72%
2005	12.94	4.13%
2006	10.70	3.80%
2007	9.86	3.79%
2008	9.54	4.10%

Source: M·E·L Textile Waste Desktop Study and Compositional Analysis

The approximate number of households in the UK is 26.5 million[23], giving a total textile quantity in the household waste stream of 539,900t per year. Textile arisings at HWRC sites are included in Section 4.4.5, but additional arisings occur in bulky collections, street sweepings and non-household textiles. Data from Resource Futures puts this as estimate of 86,000t for England alone, though there is a believed overlap between non-household waste and the commercial carpet waste accounted for elsewhere. Total additional textile waste for the UK is therefore estimated at around 75,000t, bringing non HWRC waste up to 614,900t.

Corporate clothing often has a short service life, due to frequent changes of corporate image and clothing contract renewals, and design usually changes every 2-4 years. The UK corporatewear sector was valued at £446m at wholesale prices in 2007, with 33.4m garments in use[24]. Approximately 11,000 tonnes of apparel are disposed of each year. This is not included as an additional arising, however, as the textiles involved are typically discarded

[23] M E L Research, 2009
[24] Corporatewear UK Market Study, 2007-2012, 6th edition, Company Clothing

to household waste, though corporate take-back schemes are becoming better established.

4.3.2 Mattresses

Mattresses are composed of metal, wood and fabric, and the covering and stuffing, which may be foam or soft fabrics. Between 135 and 160,000 tonnes of mattresses enter the waste stream per year, with this figure expected to rise to 160–215,000 tonnes by 2016[25]. These are a particular problem to dispose of due to their bulky nature and the difficulty of handling once soiled and wet. At present, only two companies in the UK appear to recycle mattresses. One of these, Dreams, who also manufacture, express an inability to obtain an end-market for the textile proportion due to its listing as 'contaminated' once it is used as bedding.

4.3.3 Carpet

186 million metres of domestic carpet were sold in 2007 in the UK[26]. Assuming carpet is replaced as sold, the same figure will be used as entering the waste stream. The average square metre of domestic carpet weighs 2kg, giving a domestic arising in the waste stream of 372,000 tonnes.

A problematic carpet arising is that for the event industry. Much of this is used only for a single day, or week; typically no longer. According to industry sources, approximately 6,750-8,025 tonnes of event carpet are laid each year, which equates to 50-60,000m^3 of landfill space. Whilst this is relatively small as regards to the overall figure of carpet, the short usage period leaves this in high quality condition, and recovery should therefore be prioritised.

Commercial carpet raises the total quantity of carpet entering the waste stream to around 570,000 tonnes per year[27].

4.4 Textiles diverted from the waste stream

4.4.1 Charity shop figures

The Association of Charity Shops (ACS) has a membership of 6,800 shops, the majority of the 7,500 that are reckoned to exist in the UK. A review of their members' activities and projection across the remaining outlets gives a

[25] CRR Mattress Recovery Report, 2008
[26] Carpet Recycling UK data, 2008
[27] ONS data, 2007

total of 250,000 tonnes of textiles processed through stores in 2008. This includes all donations to stores, whether directly from the public, or via door-to-door or textile bank collections. The breakdown of end use is summarised in Table 4.6.

Table 4.6: Fate of charity shop processed textiles, in 2008

End Use	Tonnage	Percentage of Total
Resale in shop	62,500-72,500	25-29%
Sale to textile recycler	175,000-185,000	70-74%
Disposal to landfill	2500	1%
Total	**250,000**	**100%**

Source: Association of Charity Shops

The Charity Finance Shops Survey 2008 had a similar order of throughput, though smaller. In discussion[28], it was noted that the survey size was of a lower number of shops (5,591) and a number of stores did not give full data; they were confident that 250,000 tonnes for all was a fair estimate, in agreement with the survey figures.

The textiles sold on as 'rag', whilst not being suitable for resale within the UK, are often of high enough quality for resale overseas. The fate of these will be discussed later in the chapter, Section 4.5. This figure is anecdotally rising due to the perceived reduction of quality as a result of cheaper, more widely available clothing, though the true extent of this is undetermined. The percentage of rag has increased from 68.7% reported in the 2001 ACS survey, to around 72% in 2008, although this actually appears to arise from a reduction in quantity to landfill than decrease in resale. Recent anecdotal evidence from industry members suggests that sales of second hand clothing through charity shops have actually seen an increase over the past months, due to lack of disposable income causing the public to be more cautious in spending behaviour. Public donations are perceived to be decreasing, due to lack of free money to replace clothing with new. Whether this becomes significant throughout the remainder of the year is yet to be seen.

4.4.2 Textile banks

As well as shop sales, charities are also responsible for a number of textile banks. Collections from these that pass through retail outlets are included within Table 4.6, but this is felt to be a small percentage of the total, dependent on the organisation. Approximately 6,500 banks are operated by charities with shops[29], and these receive around 60,000 tonnes of textiles per

28 Personal communication with Gareth Jones, Charity Finance, 2009
29 Personal communication with Lekha Klouda, ACS, 2009

year. The industry projection is for a total of 11,000 banks around the UK; and taking an average of 9.23 tonnes per bank every year gives a total of 102,000 tonnes collected across the UK. This also corresponds with the total estimated through the tonnage collected by the leading textile bank operator multiplied by the market share held. The results of a survey of textile reprocessors produced a larger quantity sourced from textile banks, of 165,000 tonnes. This is likely to be due to an over-representation of collections from banks, with a number of the major operators included in the sample survey.

For the purpose of this report, the total of 102,000t is to be used, as this is believed to be more accurate.

4.4.3 Door-to-door collections

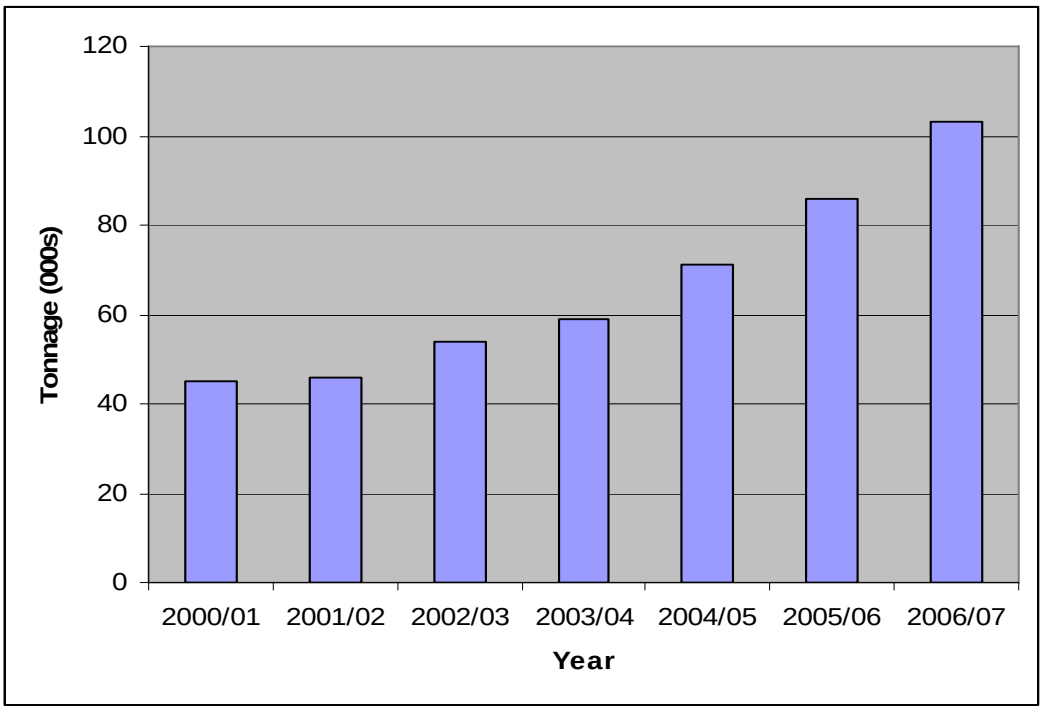
Many door-to-door collections by charities alone are sent to shops to be processed and therefore, to avoid double counting, are not listed here. However, a number of charities will partner with a commercial enterprise, allowing better recognition and reliability for the company, whilst allowing the charity to gain funding without having to organise and execute the collection itself. The textiles collected are largely sent directly overseas for reuse, with no involvement of UK shops. Results of a survey carried out on textile reprocessors in 2009 suggest that 78,000 tonnes of textiles are collected in this manner.

4.4.4 Local Authority collections

According to an Open University study, the percentage of households in the UK that are served by textile recycling has increased from 16.8% in 2002 to 31.8% in 2007. This correlates with the actual tonnage collected by Local Authorities (LAs), which is shown in Figure 4.5.

2007 saw a collection tonnage of 103,000 tonnes of textiles. However, as discussed in Section 3.5.1, LAs often use third parties to collect the materials, though it counts towards their recycling target. These third parties may be commercial waste carriers, charities, or other organisations, and therefore double counting may be an issue. In the small sample of LAs questioned, only 15-22% of credits were paid to non-charity organisations. This is again obscured, however, as many LAs do not pay credits to commercial organisations, and therefore the percentage of non-charity collections is likely to be higher. As charity collections are included in either shop or textile recycling figures, they are omitted here. A conservative estimate of 40% is taken, giving the total tonnage of textiles collected by Local Authorities, to be 41,200 tonnes.

Figure 4.5: Tonnage of textiles collected by Local Authorities in the UK



4.4.5 HWRCs

Household Waste Recycling Centres (HWRCs) are typical deposit sites for bulkier textiles, such as carpet. The M·E·L study shows that textiles at these sites have been increasing as a proportion of total residual waste (Table 4Table 4.7). According to industry data, 310,000 tonnes of domestic carpet ends up in municipal landfill or EfW, both end paths likely to be largely through deposit at HWRCs. Assuming a 5% household waste disposal (i.e. in bin), from offcuts and small pieces of carpet, a total of 295,000 tonnes of carpet is estimated to pass through these centres. Using the 2007 data of carpets comprising 63% of textiles at sites, a total textile at HWRC figure is determined of 466,000 tonnes.

Table 4.7: HWRC residual waste textile content

Year	Avg % Textile Waste	Avg % Carpet Proportion
1999	4.48%	no data
2000	2.27%	no data
2001	1.33%	no data
2002	7.22%	66.59%
2003	13.28%	no data
2004	15.34%	70.57%
2005	13.99%	75.15%
2006	12.71%	76.30%
2007	9.94%	63.14%
2008	17.57%	65.32%

4.4.6 Schools

Collections of textiles from schools is becoming increasingly more popular, with schemes such as Bag2School (run by Bag2TheFuture) and the Salvation Army Trading Company Ltd Schools Collection Scheme having great success. Industry estimates place the tonnage collected at up to 20,000 tonnes. Local Authorities often pay third party credits (typically recycling, not reuse) to schools, and therefore the tonnages are frequently incorporated into LA figures. Other organisations collecting from schools have been included within TRA figures, and therefore this tonnage is believed to be accounted for elsewhere in the report, and is not included to avoid double counting.

4.4.7 Carpets

The breakdown of domestic carpet given by Carpet Recycling UK is shown in Table 4.8.

Table 4.8: Domestic carpet EoL management in the UK, in 2007

End Use	Tonnage	Percentage
Retained	18,600	5%
Recycled/reused	1,860	0.5%
Energy recovery	15,996	4%
Landfill (MSW)	293,694	79%
Landfill (trade)	41,850	11%
Total	**372,000**	**100%**

4.4.8 Direct reuse

A fairly recent trend in reuse is the resale or donation of items directly, with no mediator. Websites such as eBay and Freecycle offer individuals means to sell or give away garments or other textiles with little traceability. The popularity of these sites suggests that tonnages passing along in this manner are significant, but actual tonnages are difficult to quantify.

Data from bigwardrobe.com on the typical number of trades in comparison to listings, gives an average of 2.6 items sold per kg of clothing listed. Allowing for double counting of organisations included elsewhere, and end of line clothing, around 1,000 tonnes of clothing per year appears to be sold through website secondary markets. See Section 5.3.2 for greater discussion of these sales.

4.5 Summary of fates of discarded textiles

Textiles are sorted into around 140 different grades by industry, with some of the pathways shown in Table 4.9. As a simplification, the five major categories are considered in the report. These are as follows:

- UK Resale
- Export reuse
- Wiper grade
- Recycling grade
- Waste.

The tonnages of textile entering each pathway in 2008 are listed in Table 4.9.

Table 4.9: Summary of fate of textiles in the UK, in 2008

End Use	2005		2008	
	Tonnage (000s)	Percentage	Tonnage (000s)	Percentage
Resale in UK	41	12.7	106	20.2
Export reuse	174	53.7	316	60.5
Wiper grade UK	28	8.6	17	3.3
Export for wiper	6	1.9	21	4.0
Recycling - UK	34	10.5	10	1.3
Export for recycling	20	6.2	28	5.9
Waste	21	6.5	25	4.7
Total	**324**	**100%**	**523**	**100%**

Table 4.9 shows the tonnage of textiles recovered in the past few years has increased by around 200,000 tonnes. Over 140,000 tonnes of this is an

increase in textiles being exported for reuse overseas, though resale in the UK has also shown a substantial growth. The final fate of the textiles exported for reuse is not fully understood however, and a proportion of the 316,000t is likely to be unsuitable for wear, and therefore either recycled or disposed of to landfill. Without greater transparency in the industry, it is difficult to determine the size of this segment. Overall, reuse as wipers and recycling of fibres has seen a decrease, though export tonnages for each have displayed an increase. The ten thousand tonnes given for recycling in the UK may be slightly misleading, however, as the actual recycling of textiles in the UK is higher than this, believed to be around 27,000t. However, much of the textile is sourced from foreign countries, or is exported as clothing and re-imported back for processing in the UK after it has been sorted and best quality pieces taken out for resale. Industry estimates put these figures as follows:

- Total UK sourced textile to recycling – 38,000t
  - 10,000t UK sourced, UK sorted and UK processed
  - 21,000t UK sourced, overseas sorted and processed
  - 7,000t UK sourced, overseas sorted and re-imported to UK.

- Total non-UK sourced
  - 10,000t overseas sourced, UK processed.

This gives a total of 27,000t that is available to process within the UK.

4.5.1 Summary of arisings and fates

Table 4.10 summarises the different methods of EoL management of textiles in the UK, in 2007. For comparison with the previous report's figures, and also due to the fairly varied disposal route (through C&I waste stream), commercial and exhibition carpet is excluded from this table.

523,000 tonnes of textiles were collected in the UK for recovery in 2007, a substantial increase over the 2004/5 data of the previous study. Only 25,000 tonnes of the textiles collected (1% of total consumption) were deemed unsuitable for any recovery option, and therefore were disposed of to the waste stream, resulting in 498,000 tonnes actually recovered.

An additional 100,000 tonnes are believed to be given away directly, between family members and friends, but as this process does not involve a third party, and is basically a life extension of the garment, the figure was kept separate from the other recovered textile data.

The figure for textiles to trade waste is largely due to domestic carpet collected by trades' people for disposal, and this figure also concurs with the Carpet Recycling UK data.

Table 4.10: Summary of arisings and disposal methods of textiles, 2007

	'000 tonnes	'000 tonnes	% of new consumption
Apparent consumption of new textiles	2,036		
Imports of used textiles	24		
Consumption of used textiles	206		
Total consumption		**2,266**	**100**
Textiles entering the MSW waste stream		**1,081**	**47**
Textiles collected for resale and recycling	523		24
Of which:			
Resale for reuse in UK	106		
Exported for resale for reuse	316		
Recycled in UK	23		
Exported for recycling	52		
Rubbish, returned to waste stream	25		
Net textiles diverted from waste stream		**498**	**23**
Textiles directly given away	100		4
Textiles to trade waste	44		2
Textiles unaccounted for		310	14
Textiles already accounted for		206	9

The overall consumption is shown at 2,266,000t of textiles per year. Due to the reuse of clothing (206,000t) already being within the system, this does not increase the tonnage to be disposed of as there is an issue of double counting. The actual quantity of textiles to be disposed of therefore lies at the 2,060,000t, and using this figure as the actual consumption gives percentage total of disposal methods as 100%, but the consumption of secondary textiles was felt to be important to highlight as an input, hence the total EoL options are shown as 91% of the total consumed, with 9% accounted for already.

As found with the previous report, a considerable quantity of textiles was unaccounted for, and believed to be part of the 'national wardrobe'. This tonnage has decreased from 397,000 tonnes in 2004/5 to 310,000 tonnes in 2007. A part of this figure may also be accounted for by incorrectly recorded disposal routes, potentially increasing figures for landfill and/or incineration.

5 Quality of Textiles

5.1 Quality of textiles in waste stream

M·E·L Research carried out a comprehensive survey of waste data from information dating back to 1999. Using an archive of compositional waste data from numerous Local Authorities, information on the types and quantities of residual waste entering landfill from kerbside and HWRC sources, from a wide geographic and demographic spectrum, was analysed. For the basis of this survey, data were used to identify the general disposal rates for kerbside residual waste and the concentrations of textile waste within it. Most households' surveys require the demographic identification of resident groups within the sample.

Figure 5.1 shows the decline in total quantity of household kerbside waste collections, from 14.98kg to 9.54 kg per household per week (kg/hh/wk), over the previous decade. Household occupancy has stayed relatively constant at an average of 2.4 people across all dwelling types[30], and it is the increase in diversion to recycling that appears to be responsible for the decrease in waste. In this period, the textile proportion has been marginally increasing, though at a slow rate. Overall, the actual tonnage of textiles in household waste per week has decreased from 0.5 kg to 0.39 kg.

The bars in the figure represent the quality of the textile within the waste (see M·E·L report in Appendix 1 for the detailed method) and it appears that the proportion of these textiles that are classed as reusable clothes and shoes has fallen from 55% in 2005 to 43% in 2008. A level of 60% was recorded in 2000.

[30] ONS Labour Force Survey (LFS)

Figure 5.1: Textiles in household kerbside collection

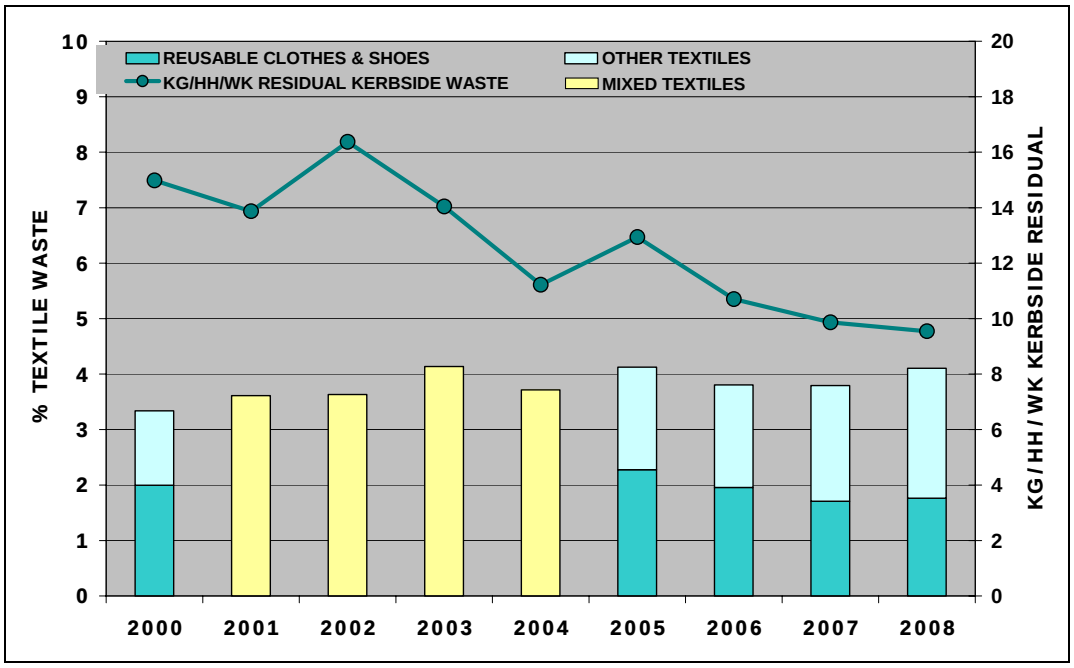
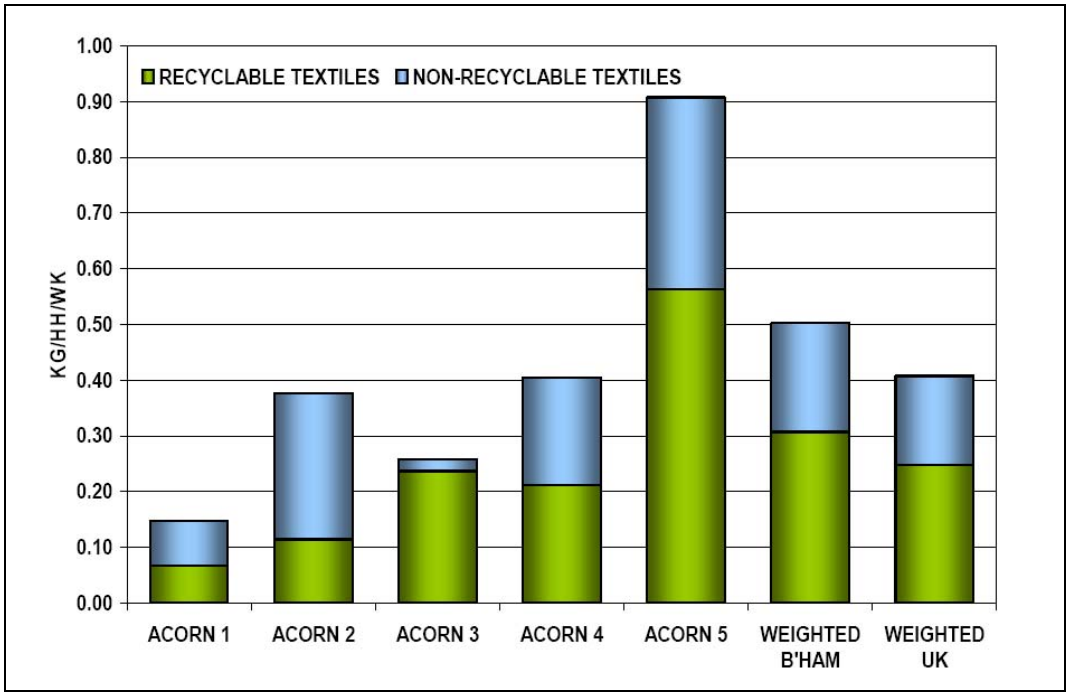


Figure 5.2: Textiles discarded according to socio-demographic group



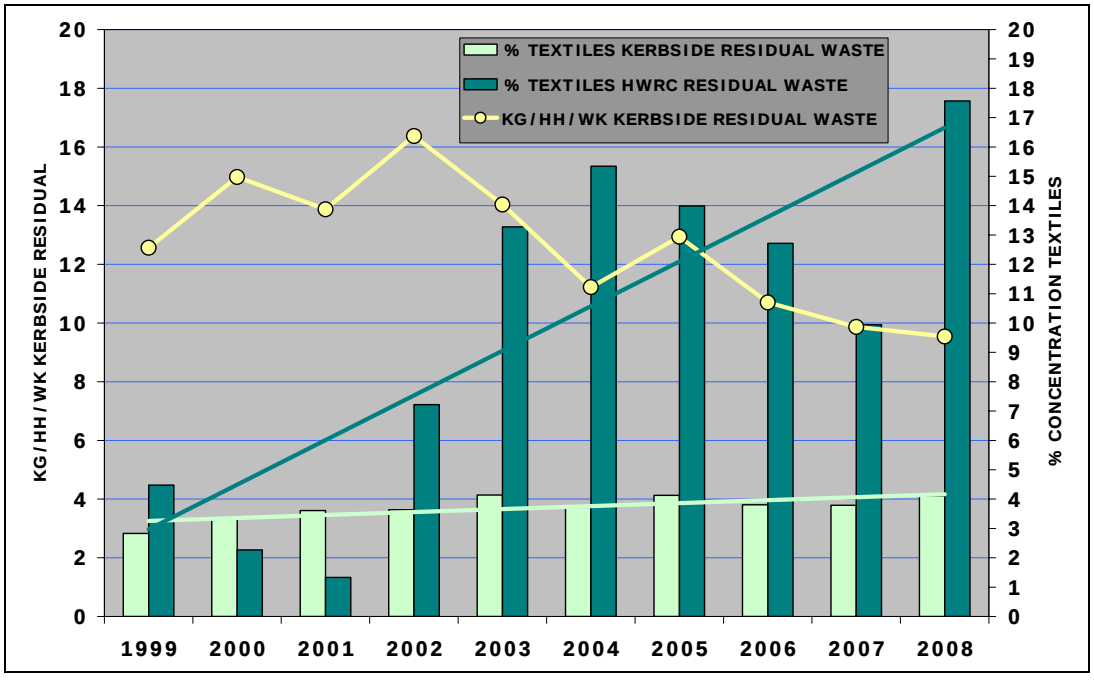
One accepted tool for demographic information analysis is Acorn listings, a system that categorises postcodes and lifestyle variables of UK residents,

based on 2001 census data, and since regularly updated. The survey sorted households into six broad categories A to F with A broadly being the most affluent householders and F the least affluent. The system was further upgraded and classifies households on a rating of between 1 and 5; again with 1 broadly being the most affluent householders and 5 the least affluent. The M E L report gives a full description of the Acorn classification system, including details of each category within it.

Using socio-demographic data, it appears that households in the lower Acorn groups discard the greatest tonnage of textiles (Figure 5.2) and the highest percentage of textiles as proportion of total waste. From the compositional analysis it is seen that each household appears to be producing between 0.15kg/hh/wk (Acorn 1) and 0.91kg/hh/wk (Acorn 5) of textile waste in their residual sacks.

Figure 5.3 shows that the percentage of textile waste at HWRC sites has been increasing fairly sharply over the decade, though year by year the values vary. As discussed in Section 4.4.5, carpet is known to be the largest percentage of textile waste at HWRC sites (65% in 2008) and therefore carpet waste offers opportunity for improved collection and recovery.

Figure 5.3: Average kerbside residual waste generation rates



5.2 Birmingham trial

M·E·L carried out an assessment of household waste discarded by residents in Birmingham in January 2009. The M·E·L Research collection team visited the designated streets on the same day and as near as possible to the same time as the usual collection. Waste from approximately 50 properties was collected from each street using bulk bags and taken away to be sorted at the designated waste site. Textiles present were sorted into specific grades for recycling, as shown in Table 5.1.

Table 5.1: Birmingham trial textile waste by recycling grade

ACORN	1	2	3	4	5	Combined	B'ham weighted	UK weighted*
% Recyclable textiles in residual waste	0.79%	2.74%	3.43%	2.14%	5.44%	3.01%	3.65%	3.08%
Proportion of textiles potentially recyclable	45.23%	30.27%	91.91%	52.17%	62.08%	56.87%	61.15%	60.80%
Recyclable element of residual textiles								
Clothing for re-use / export	51.38%	36.31%	16.99%	57.87%	47.25%	42.46%	42.11%	39.79%
Material for rags	8.87%	22.36%	1.41%	6.38%	4.65%	6.25%	5.12%	5.32%
Flocking materials	0.00%	3.76%	0.00%	0.00%	0.28%	0.49%	0.34%	0.37%
Jazz materials	8.26%	0.00%	8.27%	8.70%	5.18%	6.08%	6.14%	6.29%
Selfshade materials	8.87%	0.00%	9.60%	11.69%	10.47%	9.43%	9.96%	9.62%
Wool	0.00%	0.00%	3.52%	0.00%	0.00%	0.68%	0.73%	0.96%
Shoes (pairs) - 14	17.43%	36.31%	58.54%	8.89%	30.07%	31.73%	32.96%	35.04%
Misc recyclable accessories	5.20%	1.25%	1.67%	6.47%	2.09%	2.88%	2.65%	2.61%

There are numerous grades of recyclable textiles, but overall categories can be described as follows:

- Flocking materials – a fairly generic term when used in the rag trade, which does not identify quality or wool content. Can be 'mungo' ('a fibrous material made in the woollen trade by pulling new or old hard-woven or milled fabric or felt in rag form) or 'shoddy' ('fibrous material made from old knitted or loosely woven fabric in rag form').
- Jazz materials – acrylic or synthetic mixed colour knitted material. The fibres are usually finer than some other outer garments and the yarns used are generally softer with lower twist levels.

- Self-shade (uni-colour) materials - traditionally used for re-spinning and re-manufacturing into knitted goods, or for weaving into blankets. The fibre composition is most likely to be made up of wool, cotton, viscose and acrylic in varying amounts.

Across Birmingham around 6% of residual waste is due to textiles; the equivalent of 0.50 kg/hh/wk. Around 61% of these textiles are of a recyclable type and these materials represent 3.7% or 0.31 kg/hh/wk of residual waste.

All of the sorted textiles were grouped into sub-categories ranging from those suitable only for landfill to those with low grade uses such as industrial rags and finally clothing with immediate reuse potential.

Of the textile waste analysed from the Birmingham samples 42% of recyclable textile waste is reusable clothing with an additional 33% due to pairs of shoes – together these contribute three quarters of all recyclable materials.

Over half of the recyclable textiles in Acorns 1 and 4 were seen to be reusable clothes and in Acorn 3 almost 60% of recyclable textiles were due to shoes.

The concern that lower quality 'fast fashion' sales are likely to reduce the opportunity for reuse seems largely unfounded, as there appears to be ample available textile still suitable for reuse being discarded to bins. If it is unsuitable for wear, there is significant opportunity for further recovery through recycling processes, and therefore this is an area which would be worth focusing on to try to divert the useable resource from landfill.

5.3 Summary and recommendations

Overall, textiles in the household waste stream have shown a reduction in quantity over the past eight years, although as a proportion of total waste, the percentage attributed to textiles has increased. Textiles in HWRC sites, however, have seen a steep increase, with majority of material from carpet waste. This gives a strong opportunity to improve collection and recycling options for carpet.

Of the textiles that are discarded to the household waste bin, 60% are recyclable or reusable in some way, with 40% of that as directly reusable clothing or footwear. Lower socio-demographic groups appear to discard greater quantities of textiles as residual waste.

- Attempts by charities and waste authorities to increase the rate of diversion of clothing and shoes from residual household waste is

worthwhile and should be encouraged, particularly that lower value textiles are still worth recycling.

- Targeting of lower socio-demographic households will yield higher percentages of textiles. Partnerships with textile collectors should therefore ensure that higher socio-demographic households are not selected at the expense of others.

6 Collection, Sorting and Reuse

6.1 Historical introduction

6.1.1 Reuse

The reuse of clothing in the UK has a long tradition dating back to at least the sixteenth century. Until relatively recently, material goods such as clothing retained many of the functional elements of money, as mediums of exchange and repositories of practical value[31]. The trickle down of clothing from the more well-to-do combined with the view of clothing as not only as desirable in its own right but also as an investment whose liquidity was assured by a network of brokers and pawners. Centres of apparel dealing became established in Elizabethan times in places such as Thieving Lane, Westminster and outside London's city walls in Houndsditch. Changes in fashion could damage this investment, leading to the need to seek out secondary markets where fashions changed more slowly, both within the UK among poorer people who had less choice over their purchase decisions and overseas. In the nineteenth century, frock coats, wigs and buckskin breeches all found markets in rural Ireland and (then) British North America, having become unfashionable in England[32]. With the growth of an increasingly monetised middle classes, such purchases became restricted to poorer parts of society and the dealing networks likewise declined.

The reduction in the real value of clothing in the twentieth and twenty-first centuries has meant that clothes no longer represent a significantly realisable investment, although there does remain a latent desire for reward and a feeling of intrinsic value in the clothing. However the current patterns of clothing reuse, both within the UK and overseas, should be seen as arising from the evolution of a long historical tradition of second hand clothing flows, rather than as a recent introduction.

During the late twentieth century, the reuse markets became of greater importance to the fate of second hand clothing. This was due to a number of factors:

- The decline of the tradition recycling markets for textiles such as wipers, caused by the decline of traditional industries such as engineering and shipbuilding. This has led to a greater need for new markets.

[31] "The Second Hand Trade in England c. 1600-1850" Lemire, B. in "Old Clothes, New Looks: Second Hand Fashion" Palmer, A., Clark, H., (eds), Berg 2005 pp29-47
[32] Lemire, ibid

- The growth of a relatively prosperous middle class in many developing countries, demanding better quality or fashion than available from indigenous textile suppliers, but unable to afford new imported clothing.
- The growth and liberalisation of international trade, making exports to countries such as the former Soviet Bloc easier.
- The increasing exposure of developing and former Soviet Bloc countries to western culture, either through television/advertising or direct experience of visiting/working, leading to an acceptance of or aspiration for western fashions and brands.

6.1.2 Recycling

The collection of used textiles for recycling has also had a long history. In 1808, a letter from a paper mill in the Derbyshire Peak District in a Methodist Magazine complained …*"your petitioner humbly conceives that the inhabitants of the United Kingdom are not sufficiently careful to preserve their rags"*…., reflecting the positive value of most used textiles as feedstocks for lower grade clothing such as shoddy or mungo, or as feedstock for industrial processes such as paper making, or for wiping rags. Some of these recycling applications still exist (or have only recently ceased) in the UK, although they are more prevalent in developing countries.

Collection for recycling continued via "rag and bone" merchants and the informal recycling sector alongside the later development of charity organisations and conventional waste management. Factors influencing the recycling markets include:

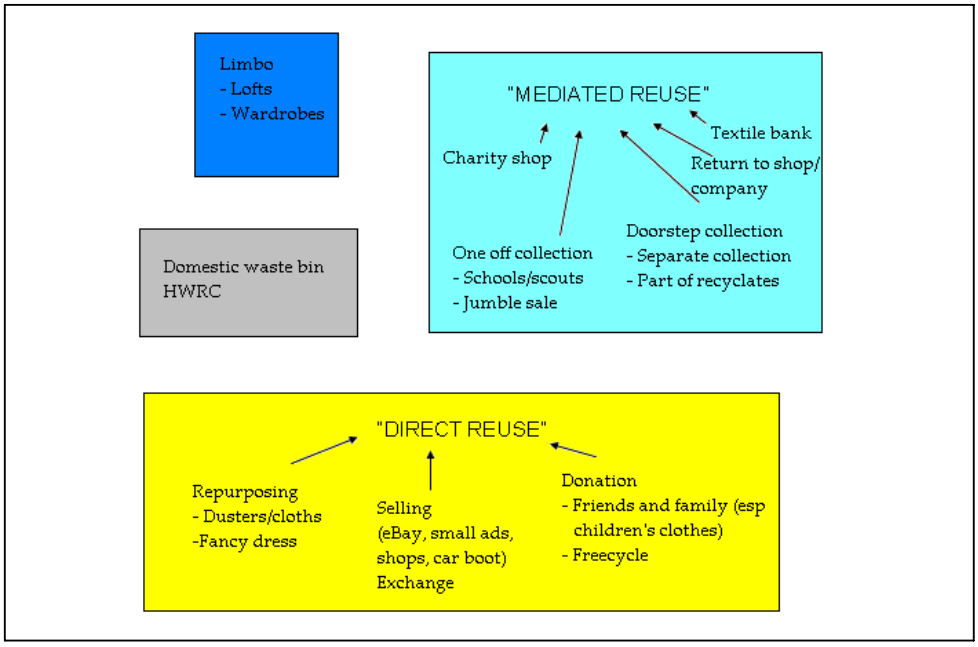
- the uptake of more synthetic polymers such as acrylics and polyesters, some of which lack robust recycling markets
- the greater use of fibre blends (e.g. with elastane) which has made recycling more difficult
- new applications in which recycled textiles can be used (e.g. automotive sound deadening)
- the decline of traditional historical UK markets for wipers such as heavy engineering, due to structural change, and printing, due to technological change.

Markets for recycled textiles are described in more detail in Section 8.

6.2 Motivating factors for disposal and exchange

The overwhelming reason why the public currently get rid of clothes is due to lack of space[33]. A wide variety of routes is available: the clothes may be put into further storage in the same house (the loft, garage, or back of wardrobe); they may be donated, sold or exchanged between individuals (gifts to friends, sold on eBay, exchanged on Freecycle) or may be given to a third party such as a charity or contractor which may be associated with the conventional waste management collection system to varying degrees. Thus these 'routes to ridding' may involve physical displacement of the clothes out of the house, or simply a mental one within it[34]. More of the latter process will lead to an increase in the "national wardrobe", as a greater stock of clothes is retained within UK houses. There is some evidence from previous research that this stock is increasing[35]

Figure 6.1: Routes to clothes disposal



Research on the public perception of sustainable clothing[36] identified the following behaviours in getting rid of clothes:

- Mainly periodic disposal patterns due to clear-outs or life changes.

[33] "Second Hand Cultures" by Gregson, N., Crewe, L., p119 Berg 2003
[34] Gregson et al, ibid
[35] Oakdene Hollins Ltd, 2006 ibid
[36] "Public Understanding of Sustainable Clothing" Defra 2008

- Only those clothes deemed fit for reuse are given to charity. There is little awareness of fabric recycling.
- Charity shops and doorstep collection are seen as most convenient, rather than selling. When recycling/reuse is inconvenient, clothes are liable to be thrown away.
- Cheap clothes are more likely to be discarded to the bin, but "expensive" goods are more likely to go to charity.
- Cheap clothes are more likely to be thrown away after a short period. There is less evidence that fashion affects length of use.
- Families and women sometimes swap clothes. Children's clothes are frequently passed on.
- Unwanted clothes are rarely sold, but eBay is an emerging market.
- There was no significant variation between different consumer segments as regards green purchasing behaviour.
- A latent desire for reward for the donation of good quality clothes.

Hence, from this research, opportunities for increasing recycling/reuse rates were identified as:

- increasing the convenience of collection
- communicating that charities can benefit from "un-reusable" clothing being recycled as fibre
- promotion of more direct exchange of clothing between individuals.

Evidence from earlier studies on second-hand goods[37] indicates that the route chosen may depend upon an individual's disposition towards philanthropy (helping charities and other people); desire for sustainability, social equity or lack of wastefulness; or the desire to make some money.

Different reasons for disposal/exchange exist for the other non-consumer clothing groups within this study:

- **Corporate clothing:** change of corporate style/identity; physically wearing out; replacement after a specified time period.

- **Carpet:** physical wear/staining; refurbishment (particularly contract carpets); change of house or office; change of fashion e.g. to laminate flooring

- **Linens, bedsheets etc:** physical wear; replacement after a specified time period (contract/textile rental).

[37] Gregson and Crewe, ibid

6.3 Direct donation, exchange or sale

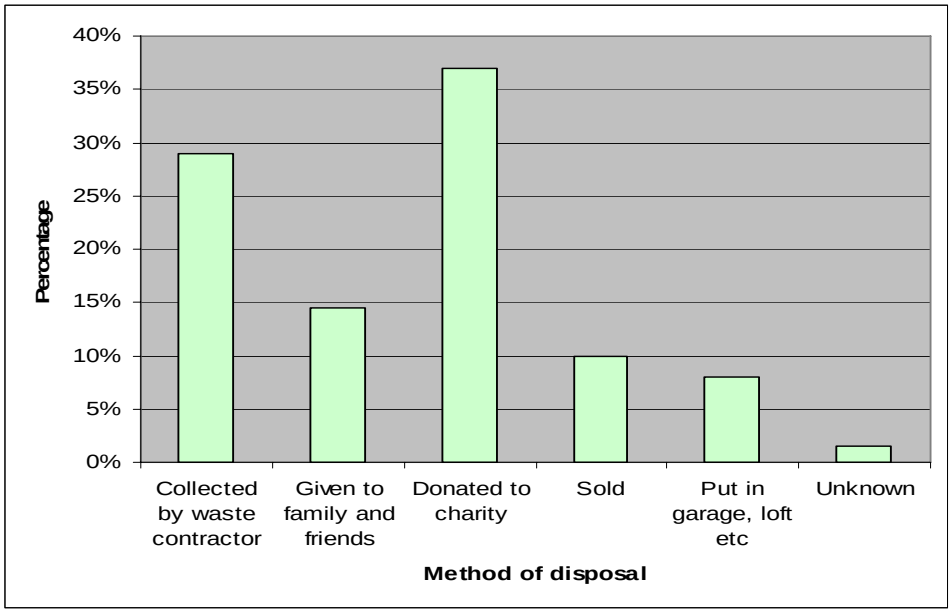
This encompasses:

- the donation of clothing between friends and family; often children's clothing, school uniforms or maternity wear
- the exchange and sale of clothing via the internet or at physical locations such as swap parties.

The key characteristic is that ownership passes from one individual to another without passing through the ownership of a third organisation. Facilitation may occur electronically via the internet or via a physical location.

Data are very scarce in this area. Indications from ethnographic studies are that if clothing followed the overall pattern of all objects got rid of by households (of which clothing forms a substantial subset), the combined total sold and donated to individuals is about the same as discarded to waste, and less than donated to charity. However it should be noted that the data in Figure 6.2 are likely to be skewed by the disposal of potentially more valuable items such as white goods, brown goods, computers and electronic goods, which were also included in the study, and are more likely to be sold than disposed of or donated. The ratios cannot therefore be considered to apply exactly to clothing, but only as an indicative guide.

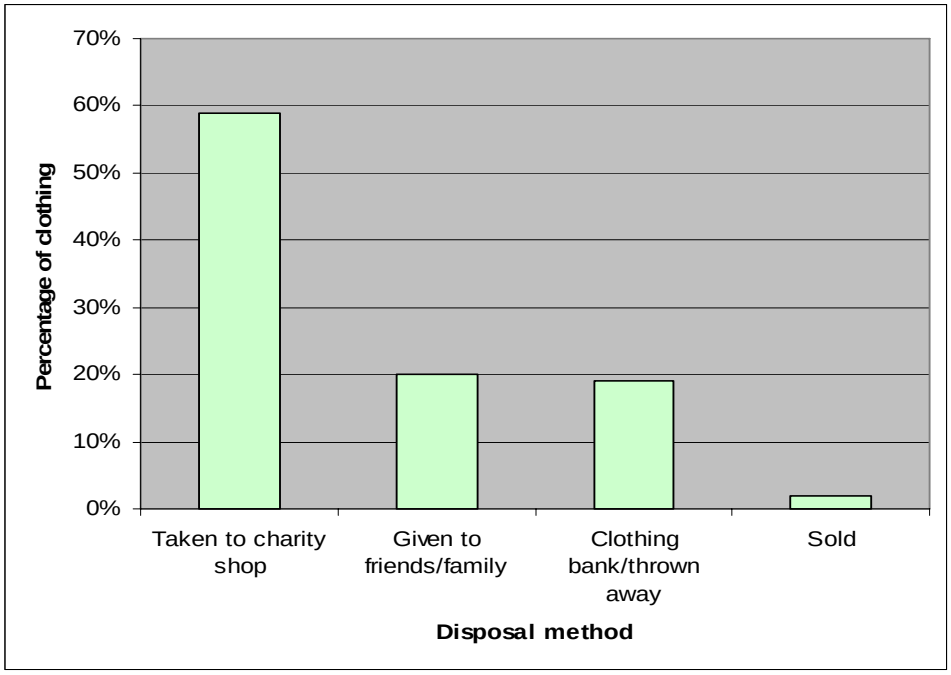
Figure 6.2: Objects disposed of by households, by disposal method



Source: "Identity, Mobility and the Throwaway Society" Gregson, N., Metcalfe, A., Crewe, L., Unpublished paper, 2008

A short questionnaire study in 2006, albeit with non-randomised selection of 250 respondents, identified broadly consistent behaviour.

Figure 6.3: Fate of clothing on "having a clear out"



Source: "Recycling of Low Grade Clothing Waste" Oakdene Hollins et al, 2006

6.3.1 Direct donation

Direct donation appears significant, but is not as high as charity donation. Since it appears that the survey respondents in Figure 6.3 underestimated the volumes of clothing sent to waste, the best comparator is likely to be the volumes sent to charity shops and textile banks. In this case, the approximate ratio of clothing donated to friends and family was just under a third of that donated to charity in both studies. This equated to around 100,000 tonnes per year in 2006. No data on trends in direct donation are available, but expectations over the long term are that donations between friends and family are declining due to:

- geographic dispersal of extended families making exchange within families more difficult
- greater average wealth combined with lower real clothing prices making clothing donation less valued by the recipient
- more frequent changes to the styling of school uniforms (which are one of the categories believed to be donated frequently) sold by major retailers and supermarkets such that "unfashionable" uniforms from previous years are readily identifiable and therefore less attractive.

However donation of items between unknown individuals, mediated by the internet through sites such www.freecycle.com, has shown strong growth – Freecycle claims a 35% increase in membership in 2007/08, giving a total UK membership of around 1.5m people.

6.3.2 Direct selling and swapping

Selling or swapping clothing appears to be of low significance in the studies cited. However recent innovations, including internet mediated sale or exchange, are a growing area: selling clothes on eBay is mentioned in a number of studies[38], and in the clothing questionnaire survey referenced in Figure 6.3 above, the proportion of respondents under thirty years old selling on eBay rose to 5% compared to 2% for the sample as a whole. The main mechanisms are:

- **Auction sites:** eBay dominates this area, with around 2.14m listings of clothing in April 2009. This compares to the next largest UK sites www.cqout.com (51,000 clothing listings) and www.tazbar.com (7,000 clothing listings). eBay contains individuals selling their own clothes, traders in second hand clothes with electronic stores (e.g. for vintage clothes), and traders selling end of line or otherwise obtained new clothing.
- **Swap and sale internet sites:** This is a strongly growing segment: www.bigwardrobe.com claims to be growing at 20% per month, with 32,000 listings in April 2009, mainly of women's clothes and bags. Approximately 75% of clothing is swapped and 25% is sold on this site. Most of the clothing is genuinely second hand (as opposed to other sites such as eBay which have end of line new clothing as well). Some items are listed on both its site and on eBay[39]. Other sites include www.whatismineisyours.com (which claims 22,000 regular users and 33% growth in swaps within two months) and www.fashionspace.com.
- **Swap events** such as visaswap (www.visaswap.com) which is organised in collaboration with the charity TRAID, a major clothes collector and seller, and swishing parties organised by or inspired by the work of sustainability public relations company Futerra (www.swishing.org). Volumes swapped physically are very low in tonnage terms, for example the last visaswap event involved 2,151 items of clothing, or around 0.8 tonnes. However such events raise the public awareness and possibly the image of clothes swapping.
- **Classified advertisements**, which may be via the internet (e.g. Gumtree.com, vivastreet.co.uk, adtrader.co.uk, preloved.co.uk) or via hard copy such as local newspapers, or free classified publications such

[38] "Public Understanding of Sustainable Clothing" Nottingham Trent University and Sheffield Hallam University, Defra, November 2008

[39] Bigwardrobe.com, private communication

as FridayAd (which is also online). Much of the clothes content of these sites appears to be end-of-line rather than used clothing i.e. they are similar to on-line market trading stalls.

- There are also **car boot and garage sales**, although anecdotally the clothes content of these tends to be low.

Hybrid approaches are also evident: for example some charities will sell items on their eBay sites on behalf of individuals, retaining a percentage of the sale price. In addition, charities will list the better items (including vintage) on their own web sites or on eBay.

Generally the lowering of advertising and transaction costs, made possible by the internet and innovations in low cost electronic payment, has made the sale, donation or exchange of even low-cost clothing possible via web sites. The increasing familiarity and trust of internet-based facilitation means that this approach is likely to increase in popularity. A continuation of average price decreases in clothing would affect this approach negatively, as would increasing relative wealth.

6.4 Bring schemes

6.4.1 Charity shops

Charity shops are a major collection and sale point for clothing. The total number of charity shops in the UK is around 7,500. Almost all of these act as collectors of used clothing, although with, an increasing number of specialist shops, not all sell clothing. Charity shop operators also use textile banks and doorstep collection methods, which are discussed later. Thrift shops collecting and selling used school uniforms are also included in this category.

Certain charity shops have introduced intermittent or permanent incentives for the return of clothing. This includes "swap shops" where the public receives credits for items returned to a charity shop which can then be spent in the shop. A recent high profile scheme has been the issue of Marks and Spencer (M&S) vouchers by Oxfam for M&S clothing returned to their stores. This has approximately doubled the volume of M&S clothing handled by Oxfam, with no decrease in quality[40]. Cannibalisation of donations to other charity shops is likely, so that the figures cannot be simply extrapolated to estimate the scheme's impact on recycling and reuse.

Although there may be some physical limitations on those shops that carry out back-of-store sorting as opposed to regional or centralised sorting, there

[40] Oxfam, Private Communication

appear to be few barriers to increased volumes of used clothing being collected through charity shops.

As outlets for resale, charity shops have increasingly diversified into items other than clothes, such as books, toys and fairly traded new items, as increasing competition in clothing emerges from low-priced new clothing suppliers such as Primark and George. However the recent high price of charity rags (the proportion of clothing sold on to textile recyclers after the cream has been removed for sale in the charity shop) has benefited charity shops as major collectors of used textiles.

Charity shops have previously complained about the increasing cost of waste disposal and the degree to which customers have given them items only fit for residual waste disposal. Therefore the communication of a desire for cheap and even damaged textiles which can be mechanically recycled, but avoiding textiles which are damp or are so contaminated they must be treated as residual waste, must be carefully managed.

The recent economic downturn appears also to have been having an affect on charity shop donations. Anecdotal evidence suggests that the public are holding on to clothing due to lack of disposable income to replace it with new. For similar reasons, purchases of second-hand clothing have increased at the same time. This was reported[41] to have resulted in "a product for the sorter of textiles that is lower in quality and smaller in quantity".

6.4.2 Textile and clothing banks

The number of textile and clothing banks in the UK is around 11,000[42]. Combined with approximately 7,500 charity shops and also HWRCs there are approximately 18,000 bring sites for textiles which form around 3% of household waste. This compares to 50-60,000 bottle banks available for glass which forms around 6% of household waste. This might indicate scope to increase the number of bring sites for textiles, however the different consumer behaviour in textile disposal (associated with more considered and periodic clear outs) must also be considered.

Temporary banks are also established by charities and contractors such as Salvation Army Trading Company, for school collections. Another example is Bag2School, who offer a scheme whereby children are given bags to take home: all the bags are returned on a particular day, when a collection vehicle will transport them away from the premises. This reduces need for storage space at the school premises. Whilst not technically a bank, the scheme is

[41] Bureau of International Recycling (BIR) June press release available at: http://www.bir.org/biruk/press/322PostDubaiTextiles.pdf

[42] Average estimate from industry, including Salvation Army and ACS, 2009

included here as it works in a similar way, with a number of individuals all bringing donations to a set point for collection. Such schemes are believed to account for around 15,000 tpa of used clothing, collected from around 20,000 schools. Most of this clothing is shipped virtually unsorted (after preliminary inspection) overseas.

Barriers to increasing the number of textile banks are identical to those for other types of banks for materials and products. Banks are familiar and widespread, and the barriers to increased deployment are comparatively low. Similarly to charity shops, there is great importance in obtaining textiles that are dry and uncontaminated, as many of these will then have to be disposed of as waste after collection.

6.4.3 In-store collection

Collection of clothing in-store has been piloted by a number of retailers who wish to make a direct impact on improving the environmental effect of textiles, but not to any significant extent in the UK. Volumes are low (totals of a few tens of tonnes), and the collections are sometimes made on a campaign basis. Some of the schemes are associated with the chemical recycling of polyester garments back to polyester yarn by key polyester or nylon manufacturers. Examples include:

- Patagonia's Common Threads Programme: garments manufactured using Teijin polyester are collected in-store or by mail for chemical recycling via Teijin's ECOCIRCLE™ Programme at a factory in Japan (see Section 7.1). This scheme is also being expanded to some nylon products.
- Uniqlo: this Japanese retailer has operated two campaigns per year for the collection of Uniqlo clothes at its Japanese stores since 2006. An earlier trial achieved 92% reuse of clothing in developing countries.
- Takashimaya: a Japanese department store chain that has run once-yearly return campaigns, resulting in an average return of 6.5 items per person, and a total of around 93,000 items, or 28 tonnes.
- Mountain Equipment Co-op in Canada accepted clothing with greater than 90% polyester content from its own brand, Polartec, ECOCIRCLE™ or Patagonia garments.
- Boomerang in Canada sells a mixture of reused and new items. Items are returned to the shops for sorting and resale for which the seller receives a percentage of the final price. There are a number of independent shops with this business model in the UK, often orientated around children's clothing.

Interestingly, the Mountain Equipment Co-op (MEC) system was discontinued after a trial period. The reasons given for this were that:

- even after a double sort (at the store and then at the distribution depot to which the clothes were returned), only 25% of the remaining clothes were accepted by the recycler, the rest being rejected due to impurities (e.g. elastane)
- many of the problems were due to identification labels that were missing or had become unreadable over time. For example in underlayer garments many people cut out the label for comfort reasons. Also, heat sublimated labels do not last sufficiently long.

Hence MEC's current strategy is to focus on reducing post-industrial textile waste in its supply chain, whilst encouraging the use of more durable labels in order to revisit in-store collection at a later date[43].

Barriers to the further uptake of in-store collection include:

- organisational complexity, space requirements and reverse logistics within the retailer
- difficulties in identification of fibre content (for chemical recycling) and consequent relatively high cost to the retailer for this route
- chemical recycling schemes are often dependent upon purchase of virgin fibre from the manufacturer and only accepting own fibre for recycling.

Enablers for this type of scheme may be the increased familiarisation with in-store take-back schemes that is likely to occur when battery collection schemes become more widespread as the Batteries Directive is implemented.

Collection of clothing is under consideration by producer responsibility compliance organisations such as Valpak, who have experience of store collection. However any voluntary strategy is yet to be determined and is dependent upon the interest and commitment of its members. No enforced EPR scheme is likely for textiles in the UK in the immediate future.

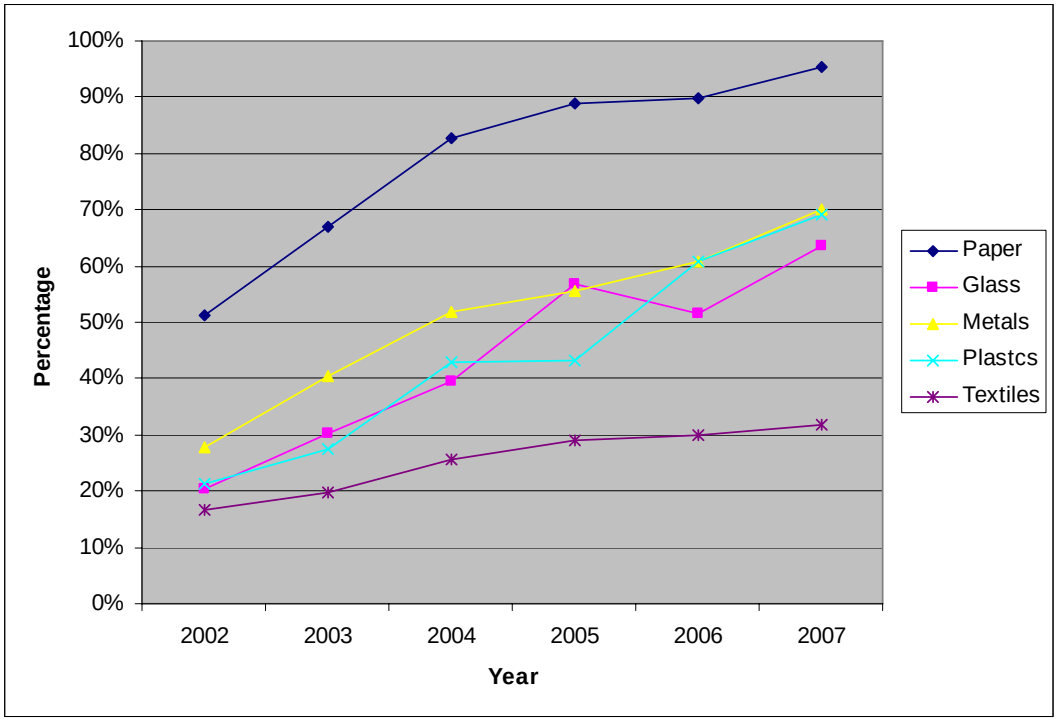
6.5 Doorstep collection schemes

Clothes can be picked up by charities acting independently of Local Authorities but with a licence to collect (or as a "rogue trader" without permission); or by contractors as part of the doorstep recyclate collection if the Local Authority is willing to collect them. The issue of double counting between the two sets of organisations is discussed in Section 4.

Doorstep collection by Local Authorities has increased, although it is still at a lower level than other recycled materials:

[43] MEC, private communication

Figure 6.4: Proportion of households served by kerbside recycling services



Source: Open University Household Waste Study 2008

Reasons for this include the relatively small volume of this waste stream compared to other recyclates; the existence of a substantial bring system of banks and charity shops; operational problems for Material Recovery Facility (MRF) operators when co-mingled with other recyclates and door to door collections by charities and commercial operators. However there are advantages in Local Authority supervised textile collections, including the inclusion of whole geographic areas which might otherwise be "cherry picked" by charities or commercial operators for the highest quality clothing only and increased confidence of the public in a nominated collector supported by the Local Authority.

6.5.1 Co-mingled collections

Modelling of kerbside collection costs has shown that the addition of textiles to certain forms of vehicle can reduce the cost of the overall collection service (i.e. create an income for the Local Authority or contractor)[44]. However if the textile is collected with the other recyclates ('co-mingled' collection) the quality of the textile is reduced through contamination and dampness, which can make it worthless to textile recyclers. Additionally MRF operators are

[44] "Kerbside Recycling: Indicative Costs and Performance" WRAP Project ROT-024, June 2008

often reluctant to take textiles as they can damage certain kinds of sorting equipment and reduce MRF productivity. Hence textiles are often excluded from co-mingled collections.

Feedback from the textile recyclers within the project stakeholder group conflicted to an extent on this issue, but generally held textiles from co-mingled collections to be of very low attractiveness. Co-mingled collection formed approximately 25% of all kerbside collection in 2005/6[45], and is forecasted to continue to grow as a percentage of all kerbside methods[46].

Therefore in order to increase textile recycling and reuse from domestic sources it is important to offer a method of exclusion of textiles from the co-mingled recyclates. It is very important that the textiles should be enclosed in a bag, either provided by the householder or the contractor. Options that have successfully been used include:

- separate collection of textiles by a textile recycling contractor or charity, often following the recycling vehicle. Bags distributed separately by the textile recycler beforehand.
- Co-mingled collection of glass/plastic/cans but collection of paper and textiles (or textiles only) in a single use bag for separate sorting at the MRF or for sending to a textile recycler.

6.5.2 Other collection methods

There is a general preference for systems other than co-mingled. Successful doorstep collection schemes indentified by contractors that produced high quality, desirable textiles included:

- bags supplied by the contractor
- rebagging if necessary to keep dry and to identify correctly
- storage separately under cover at MRF / transfer station
- possible collection with paper, but no other recyclate.

Ready identification of the contractor's bags also helps somewhat to reduce the collection of textiles by other parties. Given the current high value of used textiles, the problem of collection by opportunistic third parties was mentioned by industry stakeholders involved in collection.

[45] "An Analysis of MSW MRF Capacity in the UK" WRAP Report BUS013, June 2007
[46] WRAP, Private Communication, February 2009

6.5.3 Reduction of waste

The waste hierarchy clearly defines that, above reuse and recycling, the initial reduction of waste is typically the more environmentally beneficial option. Whilst difficult to quantify, there are a number of opportunities available to reduce waste created in the textile industry. There are clear post-industrial resource efficiency measures available, but this study focuses on post-consumer, and therefore product life extension is most likely the key opportunity. By designing and producing high quality garments, that are efficiently cut and therefore fit an individual well, the consumer is less likely to dispose of an item casually, and therefore does not need to replace it so quickly. This is also true of garments with durable fibres selected for manufacture, particularly in those garments that will get heaviest wear – such as some uniforms and corporatewear.

Another potential life-extending opportunity is the laundering of damp or contaminated clothing found in MRFs. This is a complex issue, with in-depth trials recommended for any realistic understanding of opportunity in this area.

6.6 Sorting

6.6.1 Sorting infrastructure

There has been a generally accepted decline in the amount of sorting of textiles that takes place in the UK and a consequent growth in the sorting that takes place overseas, notably in former Soviet Bloc countries such as Poland, Lithuania, Estonia and Ukraine. UK companies carry out different degrees of sorting, for example:

- full sorting to include recycling grades/wipers, cream, export grades, carried out by companies such as Wilcox, LMB, Nathan's, Oxfam, Wastesavers
- partial sorting with fewer categories, for example as carried out by IG Cohen
- scanning to remove obvious rubbish only before shipment, for example as carried out by Salvation Army/Kettering Textiles.

This has been influenced by the lower cost of sorting overseas, and the growth in overseas demand for UK clothing relative to UK demand, particularly for recycling grades.

The stakeholder group was of the opinion that sorting capacity within the UK was useful in achieving environmental goals, in that it gave greater flexibility in the directing of textiles to reuse or recycling, and therefore

greater resilience to market changes. There are some parallels to the growth in overseas demand for UK recyclates such as mixed plastics and paper, much of which is shipped to China for reprocessing. Whilst this is frequently the most profitable route, with low additional environmental impact, it does expose the UK to more volatile swings in demand that may act against the establishment of stable markets.

Interviews with industry recyclers gave different opinions as to the degree of use of the clothing when it was sorted overseas – that it could lead to less or to more recycling/reuse. It was not possible to obtain data from overseas recyclers to refute or validate these claims. However, since in developing countries such as India and China there are known to be very highly developed textile recycling industries with very little wastage, it might be expected by extrapolation that countries such as Poland which are more developed, but less wealthy than the UK, would have a recycling infrastructure that was well developed.

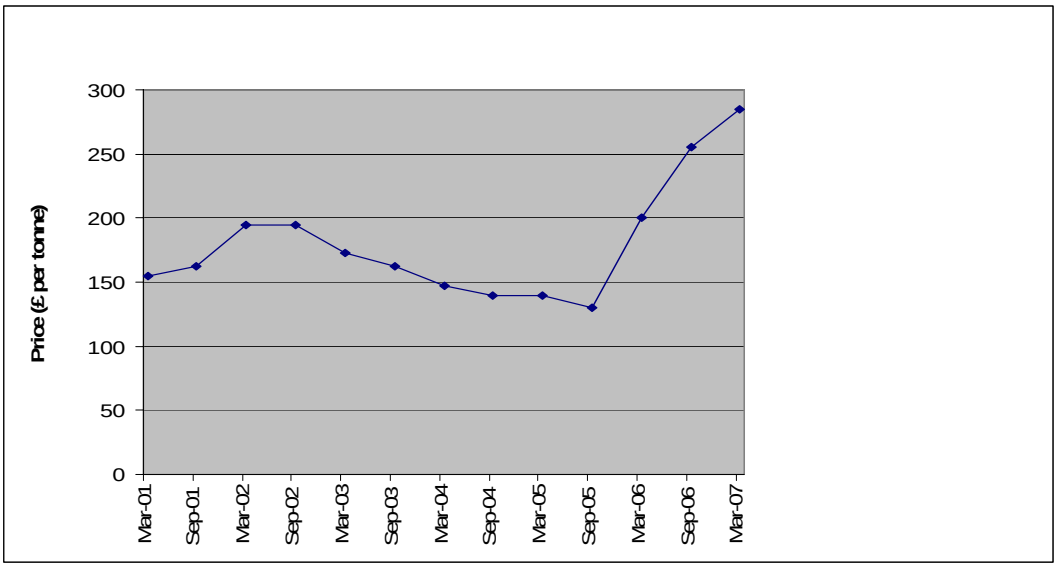
6.6.2 Sorting economics

The situation for recycling and reuse outlined in Section 4 is of continuing strong demand for second-hand clothing from Sub-Saharan Africa, the recent historical markets for UK clothing, combined with strong demand from the former Soviet Bloc countries. These countries also increasingly offer sorting facilities, encouraging the decline of UK sorting. The overall very strong demand for used clothing has led to historically high prices as of April 2009. It should be noted however that the textile recycling market is cyclical in nature and that cycles of high and low prices have been experienced previously. The strong overseas demand has currently more than offset other negative trends in UK used clothing such as the decline of certain recycling markets, competition from cheap virgin clothing and lowering of the quality of used clothing. It remains to be seen whether the same factors of economic slowdown that adversely affected the other recyclate markets dependent upon overseas demand such as paper and mixed plastics, will also cause a reduction in demand for clothing. Our view is that the drivers in the case of clothing are less dependent upon commodity and raw material demand and more dependent upon the size and prosperity of the emerging middle classes, who form the bulk of the overseas markets for UK clothes. Therefore although there may be some reduction in pricing, we do not expect the abrupt reduction in pricing and in demand experienced by some recyclates. Anecdotal evidence[47] suggests traditional buyers in Africa are struggling with foreign currency exchange and securing sales. There is some industry concern this may start to push down prices for the future as it may be that clothing prices are currently at the peak of their cycle.

[47] Terry Ralph, former president of TRA, as reported in BIR June press release, available at: http://www.bir.org/biruk/press/322PostDubaiTextiles.pdf

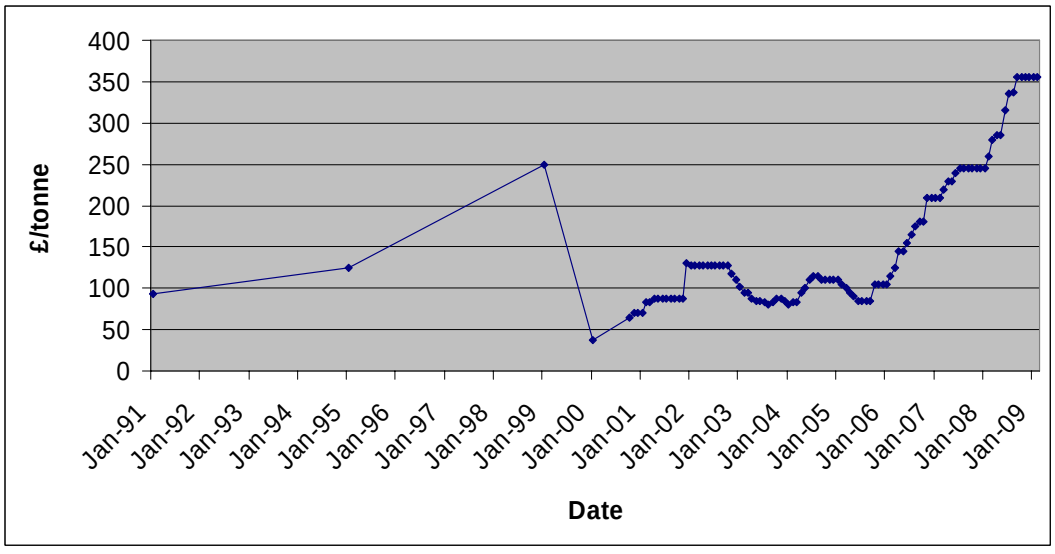
Prices paid for "charity rags" – those clothes left after the charities have selected the clothes for UK resale – have risen in the past few years. In the longer term, the market shows cycles of high and low pricing, as shown by the data going back to 1990 Sample data is limited before 2001 due to lack of available historical data from TRA members. This is "shop collections", which is a slightly different measure to charity rags, but almost exactly correlated. Therefore it appears highly likely that at some point the cyclical nature of the industry will result in lower prices.

Figure 6.5: Variation in price of charity rags from 2001 to 2007



Source: letsrecycle.com

Figure 6.6: Variation in price of shop collections from 1991 to 2009



Source: TRA

These charity rags are purchased and sorted by textile recyclers and then sold on to achieve the range of prices shown in Table 6.1.

Table 6.1: Rag sales prices

Sales price per tonne		1990	2005	2008	2009 (March)
Recycling Grades	White wipers	£600	£200	£190	£100
	Other wipers	£150	£50	£30	£100
	Wool knits	£500	£300	£170	£400
	Uni-colour acrylic knits	£220	£110	£50	£100
	Filling materials	£100	£30	£40	£50
Clothing Grades	Clothing for reuse Africa	£1,000	£900	£880	£1,100
	Clothing for reuse Pakistan	£220	£200	£200	£100

Source: Industry estimates

This shows a reduction in prices for recycling grades that is consistent with the static or declining UK recycling markets and the better performance of reused clothing sent overseas.

Problematic grades include:

- Denim recycling grades. There are very limited outlets for this short fibre material, which only command very low prices.
- Personal protective equipment (PPE) for which overseas markets are only just starting to appear (except in some special cases such as firemen's clothing).
- Wax jackets, for which there is no market.
- Polyester, polyester/cotton mixes and acrylics where the only market is usually in flocking or shoddy.

Rags containing high proportions of wool are desirable, due to applications such as mattress flocking where the natural flame retardancy of wool removes the need for synthetic flame retardants. Combined with the reduction in the weight and availability of woollen clothing, these recycling grades have performed better than most. Existing and new markets for recycled textiles are further described in Section 8.

Without intervention it appears probable that an increasing amount of sorting will take place overseas due to relatively weak UK recycling markets and UK reuse markets that are likely to weaken in the long term. However a proportion of UK sorted clothing does appear to be beneficial as regards market stability. Possible interventions include:

- voluntary agreements on UK sorting e.g. a condition of membership of the TRA
- innovation to create new UK markets for recycling grades.

6.7 Reuse markets

6.7.1 UK markets

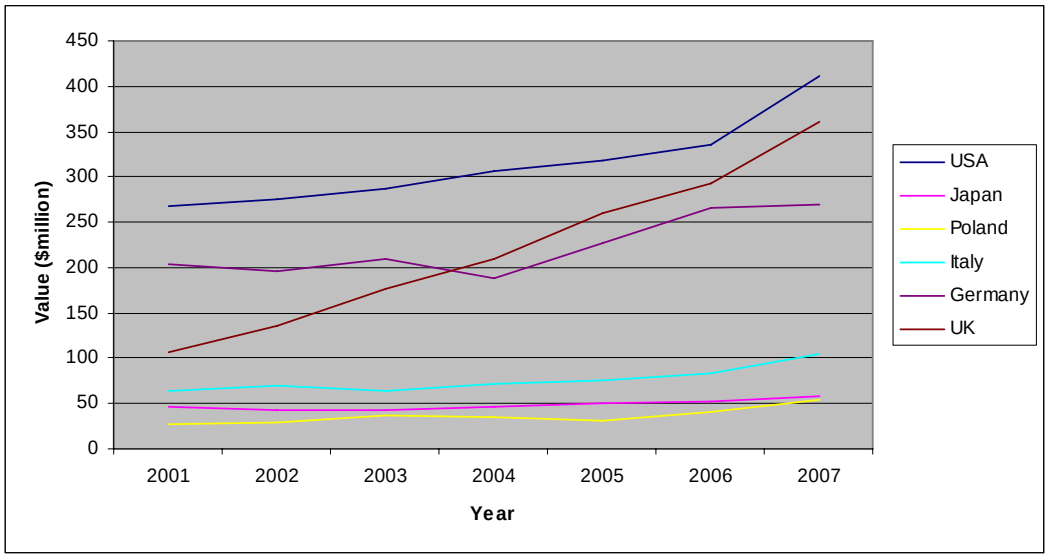
The direct UK market for reuse has been described in Section 4. Almost all other sales in the UK are through charity shops, comprising the "cream" that is removed from charitable donations for UK sale prior to the residue or "charity rags" being sold on to commercial recyclers. This has increased in percentage and in absolute terms since 2003.

Competition comes mainly from low cost clothing suppliers such as Primark, George and Tesco. Reductions in the prices of these clothes and the increasing popularity of these chains has meant consequent reduction in margins of charity clothes, although clothing sold in the UK remains highly profitable compared to that sold overseas.

6.7.2 Overseas markets

As with many other recyclates, the main overseas markets for used clothing have shown substantial growth. This is in line with the increase in UK textile recycling and reuse and the increasing export of unsorted clothing. Trade in used clothing generally has increased, but exports from the UK disproportionately so compared to other countries, with exports more than doubling between 2003 and 2007:

Figure 6.7: Exports of used clothing from selected countries



Source: ONS

The main concerns with promoting overseas markets have been the adverse effect of used clothing on indigenous clothing manufacturers in developing countries. This has been raised from time to time by charities such as Tearfund. These concerns have been researched in a number of studies that have been reviewed previously[48]. The conclusions are generally that the second hand trade creates substantial local employment through distribution and trading and is of net benefit to the countries studied. The view of textile researchers active in developing countries is that used clothing is a contributor to the demise of local manufacturing, but that other factors such as cheap virgin clothing, management competency and national governance also were important. For example in some countries there was the belief that the quality of imported used garments was likely to be better than locally manufactured goods[49]

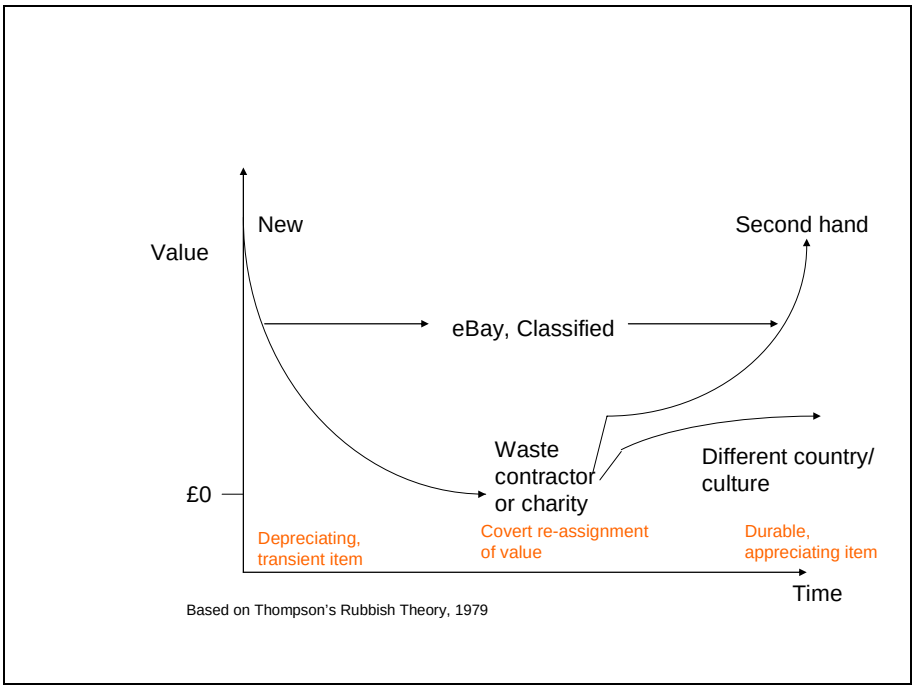
Social science researchers also note that second hand clothing is not "dumped" into developing countries, but that it undergoes a process of transformation into local clothing. *"What begins as charity with donations of used clothing in the West becomes a whole industry that draws in countries like Zambia not as passive receivers of the West's surplus clothing but actively involved in shaping the nature of the trade. The relationship revolves around a process of recommodification in which the meaning of second hand clothing is redefined in local terms"*[50]

6.8 Models of clothing discard and exchange

Disposal routes can be transferred through a third party such as a charity, commercial textile recyclers or waste disposal contractors, or can be direct, for example donation to family members, or mediated electronically via eBay. According to Thompson's Rubbish Theory[51] the transition of products through the category of "rubbish" enables the radical reassignment of value to a product that is depreciating, into one that may appreciate in value. This revaluation can be explicit and transparent (for example the sale of charitable clothing in the UK) or more opaque (sale of clothing overseas). This is represented in Figure 6.8 below.

[48] Oakdene Hollins 2006 ibid
[49] "Second Hand Clothing in the Philippines" Milgram, B.L. in "Old Clothes, New Looks" ibid p 149
[50] "Crafting appearances: the Second Hand Clothing Trade and Dress Practice in Zambia" Hansen, K.T., in "Old Clothes, New Looks" ibid p116
[51] "Rubbish Theory: The Creation and Destruction of Value" Thompson, M. , Oxford University Press, 1979

Figure 6.8: A model of value reassignment



Types of direct sale and exchange such bigwardrobe.com and eBay avoid this reassignment and allow a more transparent renegotiation of value between buyer and seller.

6.9 Collection systems for other textiles

6.9.1 Speciality textiles

Recently the American ski gloves and mittens manufacturer Swany America Corporation announced a closed-loop recycling programme for used polyester gloves based on envelope collection, supplied at the time of purchase. Swany is to use Teijin's EcoStorm® product made from recycled fibres laminated with polyester film and should be available from September 2009.

Customers will be invited to mail their worn-out ECO-X gloves to Swany America using special envelopes supplied at the time of purchase. The gloves' polyurethane palms will be cut off at Swany Warehouse in Johnston, New York and recycled domestically. The remaining polyester parts, such as shells, insulation, waterproof and breathable inserts and hollow core inner linings, will be sent to Teijin Fibers' Matsuyama plant in Ehime Prefecture, Japan, where they will be chemically decomposed and converted into new polyester raw material at a recycling facility.

6.9.2 Corporate clothing

Corporate clothing and uniforms comprised around 33m garments purchased, with an average contract length of around 2-4 years[52], ranging from the construction industry for workwear and PPE, to retail for corporate uniforms. There are also very large individual users such as the NHS for nurses' uniforms, sheets and curtains/drapes. The total volume disposed of is around 11,000 tonnes, with a recycling and reuse rate much lower than that for conventional clothing; thought to be less than 10%. Particular issues for corporate clothing include:

- high levels of fibres such as polyester and nylon which are included to give hard wearing clothing
- use of blends such as small quantities of elastane for fit and fashion reasons
- the need to remove or at least control circulation of clothing with logos for security and branding reasons. Some customers insist of complete shredding/destruction for security.
- the need to dispose of large quantities of identical clothing over a short period of time
- the requirement by HMRC for a "prominent and permanent" logo or other indication that the corporatewear is indeed a uniform. This is often met by the use of "tax tabs" which can be discrete. A major problem is the differing interpretation of this rule by different tax offices and inspectors.

These factors tend to restrict the attractiveness of corporate clothing to textile recyclers. Often such clothing is "blended away" in small quantities with conventional clothing at the sorting stage, but large quantities are usually refused by recyclers, and must be landfilled/incinerated if they cannot be recycled mechanically. In addition some clothing, notably PPE, has almost no overseas market due its lack of use in developing countries. Thus the recycling/reuse rate for corporate clothing is much lower than that for conventional clothing.

Corporate clothing that is required to be destroyed for security or branding reasons is usually collected by the client and then passed on to a textile recycler (or sometimes a security shredding company) for shredding and then is either mechanically recycled into nonwoven products, or is incinerated/landfilled.

Whilst some options are available for de-logoing branded garments, these tend to be very resource- and time-intensive, and therefore not currently

[52] Source: Company Clothing Magazine

economically viable on a large scale. Often the process of removing a logo can damage the material, making reuse value lower.

A recent study on taxation issues[53] explains that, while some corporatewear purchasers may see the requirement for a logo or tax tab as quite outdated, the HMRC stresses the need for such items to ensure that private clothing is not falsely claimed as business corporatewear. For the reasons given above, this causes a significant barrier to reuse of clothing, yet no alternative has yet been accepted.

There are factors within the corporate clothing market that give it potential for improved end of life management:

- Corporate clothing customers (particularly those with public facing operations) increasingly accept responsibility for clothing issued to employees as part of their CSR rather simply being leaving employees to dispose of it.
- Managing agents who are controlling clothing for a variety of clients have the opportunity and logistics to take back clothing and to direct it down a number of different reuse or recycling routes.
- The potential for receiving back a large number of clothing items with the same fibre composition makes chemical recycling routes, which are generally more intolerant of other fibres than mechanical recycling, more attractive.

Collection, recycling and reuse systems for corporate clothing are described in greater detail in the Corporate Clothing Project undertaken by the Centre for Remanufacturing and Reuse (www.remanufacturing.org.uk or www.uniformreuse.co.uk) and completed in April 2009. This includes research on logo removal (which is also being taken forward in a separate project originally funded by the Centre and now by the Technology Strategy Board); on sustainable fibre choice; on debondable seam construction; and best practice case studies on used clothing management.

6.9.3 Textile rental

Textile rental includes much of the corporate clothing described above but tends to require more regular or more thorough cleaning. Examples include chefs' uniforms and engineering overalls. Also included are other hospitality linens such as hotel bed linen, restaurant tablecloths and napkins; entrance mats; and specialist clothing such as clean room overalls. In this case, all of the textiles are returned to the textile rental company at end of first life, when they are usually recycled into wipers (the fate of much bed linen) or disposed of to landfill/incineration.

[53] Taxation issues in Corporatewear, 2009, CRR

Problematic materials for textile rental companies include:

- **Mats**, which are usually nylon, polyester or cotton bonded to a rubber backing. There is currently a European project examining the collection of these, but disposal is only to incineration. There has also been recycling of the mats at pilot plant scale in the UK using cryogenic technology.
- **Clean room uniforms**, due their anti-static properties which make conventional recycling difficult.
- **Engineering overalls:** There has been previous (unsuccessful) experimentation in Scandinavia by one of the large textile rental companies in reusing the overalls from aerospace engineering for automotive engineering, but the difficulty of logo removal meant that security concerns ended the trial.

Provided that technical problems can be overcome, textile rental provides a good testing ground for textile recycling, due to the reverse logistics that already exist from the customer to the textile rental company.

6.9.4 Carpets and carpet tile collection, remanufacturing and reuse

Collection of used carpet is in its infancy in the UK. Since the failure of the Wrace carpet recycling company on Merseyside about seven years ago, carpet manufacturers have been reluctant to back another initiative. However the formation of Carpet Recycling UK has given this new impetus. Companies such as Greenback have been establishing recycling facilities that can accept carpet from HWRCs (the disposal point for most carpet that is not disposed of as construction waste in a skip, or as C&I waste by the contractor). According to Carpet Recycling UK a number of investors are joining established companies such as Greenback and Spruce Carpets to invest in identification, sorting and size reduction equipment that will create geographically dispersed carpet recycling locations with a predicted capacity of 20,000 tpa by mid 2009 (compared to total UK arisings of around 570,000t).

Direct reuse of carpet is usually limited by the condition of the uplifted carpet: most carpet being uplifted at the present time is, on average, 10 years old or more. Hence reuse strategies occur more often with carpet tiles, where it is easier to uplift, refurbish and sell on. The refurbishment process includes cleaning and retexturing, but can also include deodorising and overprinting. Major carpet tile manufacturers Interface Floor and Milliken are heavily involved with initiatives to increase reuse (and recycling) of carpet tiles both individually and as members of Carpet Recycling UK.

In addition to its *Evergreen* leasing system, Interface has a carpet reclamation process: *ReEntry*™[54]. Through this scheme, Interface will arrange for any Interface carpet tile to be collected from the customer for a small fee. Reclaimed products are then refurbished through two social enterprises: Green-Works in London and Spruce Carpet in Glasgow. Products that are considered unsuitable for the refurbishing process are, where possible, recycled into new products or downcycled into lesser value applications. Once processed through the partnering organisations, the refurbished carpets are donated or sold on to the voluntary sector, schools and churches, or refurbished tiles are used in small businesses and or even specified by commercial architects. The *ReEntry* scheme has been in place for five years in the UK and Interface are now expanding into other European countries, namely France, Germany and Holland. Since being launched in the USA in 1994 the *ReEntry* scheme has diverted more than 7 million m² of carpet from landfill worldwide. In the UK the *ReEntry* scheme prevented 126,000 m² from being sent to landfill in 2008, an increase from 94,000 m² in 2007.

Milliken has introduced an *Earth Square*™ programme which reclaims used commercial carpet tiles and remanufactures them to 'as new' condition. This is achieved through a three step process that cleans, re-textures and overprints the original tiles with the Millitron dyeing process to disguise any irregularities or marks. Customers can either have their own tiles renewed for reuse or specify and purchase renewed carpet tiles from Milliken's Modular Resale stock. One drawback of this process is that patterns can be added but not taken off, as this involves the use of substantial amounts of bleach which would be counter-productive to the overall aim of reducing the environmental impact of the product. However the Millitron overprinting technique works well and can update the look of any interior simply and effectively.

This process allows for the product to achieve multiple lifecycles and also incorporates a 10 year guarantee at the beginning of the next usage period. At present end-of-life carpet tiles are shipped to the Milliken plant in the USA for processing. The *Earth Square* scheme is currently operating on a relatively small scale in the UK although demand is growing each month. If a critical mass of *Earth Square* tiles can be collected in the UK it is possible that Milliken will set up a processing facility in the UK.

Spruce Carpets was established in 2004 to refurbish carpet and carpet tiles from the greater Glasgow area and sell them on to voluntary sector organisations, small businesses and schools. Processing approximately 6,000m² of carpet and 2,000m² of carpet tiles per year, Spruce Carpets were responsible for diverting around 150 tonnes of carpet waste from landfill in 2007. The service is advertised by local carpet fitting companies to customers

[54] http://www.interfaceeurope.com/Internet/otherfiles.nsf/Lookup/ReEntry_EN/$file/ReEntry_EN.pdf

having new carpet fitted who then telephone Spruce to arrange for the old carpet to be collected. Waste carpet is also accepted from fitters who are able to avoid landfill costs by donating the carpet for recycling. As previously mentioned, Interface and Milliken also donate uplifted carpet tiles to Spruce Carpets for refurbishing. The carpet tile programme has been running since May 2006 and around 10-15 pallets of carpet tiles are received from Interface each month, equating to between 5 and 7.5 tonnes, and it is anticipated that this will increase to between 15 and 20 pallets per month in the future. Approximately 60% of the tiles are able to be reused and the remainder are advertised on the Glasgow Freecycle website. Tiles are sold either through their own dedicated eBay site or through their showroom at the factory site. Other products include a weed suppressant made from offcuts of wool carpet with natural fibre backing.

Recently Launchpad in Scotland announced the introduction of a new carpet uplift and refurbishment scheme in the Perth and Kinross region. The 'House and Home' service, funded by the Scottish Executive Strategic Waste Fund, provides a free removal and collection service for end-of-life carpet and floor tiles. They accept donations of quality, reusable carpet and once refurbished, these are sold on at discounted prices to people on low incomes. Any carpets that are unable to be refurbished are recycled if possible, and most donations will be collected free of charge.[55]

Reuse of carpet other than in the social enterprise and charity sector operates on a small scale although there is evidence of this occurring. BioRegional have produced a number of case studies on reclamation and reuse of building materials in demolition[56]. One project, the demolition of Wembley Conference Centre, resulted in a number of items being reused, including carpet. With assistance from NISP, materials were matched to suitable end users and the reclaimed carpet was reused at the local Hilton Hotel.

With regards to commercial collection of used carpet products, there are few services currently on offer in the UK. FullerGray Carpet Tiles (formerly Carpet Tiles R Us), based in Cambridgeshire, was established in 2004 to support the reuse of carpet tiles as well as supply new ones. Offering a free kerbside collection service to SMEs and building and construction contractors, carpet tiles are refurbished and donated to charities, schools, community centres and churches with 95% of carpet tiles collected being reused. Carpet tiles are also accepted as part of Milliken's *Earth Square* programme. This is an interesting example of on-site collection and although currently operating on a small scale this could easily be replicated and similar initiatives could be set up in other regions of the UK.

[55] Launchpad Enterprise and Training http://www.launchpadtraining.org/Press/tabid/204/Default.aspx
[56] Reclamation Led Approach to Demolition, BioRegional, July 2007

Recycling and the creation of new markets for recycled fibre are discussed in more detail in Section 8. Markets under investigation by Carpet Recycling UK include new uses for wool-based fibre such as peat replacement, compost and land remediation. Barriers to their adoption include the need for environmental and human health risk assessments and possibly the need for standards and "end of waste" criteria.

6.10 Conclusions and recommendations

- Perceptions of the "dumping" of the West's surplus clothing on lower income families in the UK and overseas do not reflect accurately the long tradition of trade in used clothing.

- Previous research on consumer behaviour has identified opportunities to increase recycling by increasing the convenience of textiles collection; by communicating that cheap or damaged clothing has value to a charity or recycler and should not be disposed of as residual waste; and by the promotion of reuse between individuals. Charities and recyclers should encourage customers to donate cheap and damaged clothing, but avoiding increased collection of contaminated or damp clothing.

- Direct reuse within family/friendship networks is significant, but may be declining. Exchange or sale between individuals facilitated by the internet is growing strongly, albeit from a small base. Combined with evidence of innovation and hybrid approaches, continued growth is expected. Encouragement of classic styles and slowly changing fashion (e.g. within school clothing) will assist this. The latter issue could be addressed by DCSF (Department for Children, Schools and Families) in discussion with retailers over retention of similar styles over several years. This will also make thrift shop operations within schools more effective.

- Use of textile banks is growing as a collection method for used textiles. There are no significant barriers to the expansion of these schemes so long as the economics of textile recycling remain attractive. Charity shops have remained at a fairly consistent level in recent years, and no significant expansion is expected in the near future.

- Charity shop incentive schemes, such as the M&S and Oxfam voucher scheme, act as good models to increase donations without reducing quality of textiles.

- There is little or no UK experience of in-store collection. International experience is of both continuous and campaign collections. Continuous collections allied with synthetic fibre recycling have experienced some

problems with consumer awareness, identification/labelling and the consequent costs. Familiarisation with other in-store collections (e.g. batteries) may change retailer perceptions.

- The availability of kerbside collection of used textiles has almost doubled since 2002 to over 30%, but is still only half of that for glass, plastics and metals. Previous consumer behaviour studies show that convenience is a major factor in increasing recycling/reuse rates for clothing. A greater proportion of LAs should offer kerbside collection of textiles so that recycling availability matches that of other recyclates

- The growth of co-mingled household collections is a threat to greater recycling and reuse of textiles, as textiles are unattractive to MRF operators and the collection methods result in the poor condition of the textiles. Where co-mingled collection takes place, LAs should introduce alternative textile recycling offerings such as partnerships with commercial textile recycling companies to collect textiles separately and in good condition

- Lower levels of UK sorting and the direct shipping abroad of unsorted clothing is increasing, encouraged by robust overseas reuse and recycling markets and declining or stable UK recycling markets. A level of UK sorting is desirable in order to service UK markets and also to reduce risk of exposure to overseas trading markets. Experience with other recyclates has shown that such markets can be volatile, although this can be reduced by offering higher quality products/materials. Greater transparency on fates of clothing is required from individual companies and from trade organisations. Interventions such as innovation funding, demonstration projects and capital equipment grants should be used to create new markets for recycled fibre in the UK.

- Collection and reuse/recycling of corporate clothing at end of life is lower than with conventional clothing due to the large volume of identical clothing, security and branding concerns and tax treatment. There are also opportunities due to its consistency, the increasing management by companies at end of life and increasing awareness of its environmental impact. Use of public procurement initiatives to increase the overall sustainability of corporate clothing used in the public sector, including improved end-of-life management. This might include a demonstration of closed loop recycling or reuse. Greater consistency in the application of tax rules to corporate clothing, with more detailed guidance on what constitutes acceptable corporate identification that also maximises the potential for reuse. Increased collection of used corporate clothing by companies or their agents is recommended rather than encouraging employees to dispose of clothing themselves.

- Textile rental already possesses the collection infrastructure for efficient recycling. Particular problems remain with some products such as mats and specialist uniforms such as for clean rooms. Market development via innovation or demonstration funding for specific problem products will help increase recycling rates in this sector

- A carpet collection infrastructure is being created to accept carpets from HWRCs, albeit from a small base, facilitated by Carpet Recycling UK. There is a small existing collection, sorting and reuse/recycling industry, often based on social enterprises and often supported by a large carpet tile manufacturer. There are also larger scale recycling and reuse opportunities in carpet tiles, currently shipped to the USA. Market development via innovation, demonstration or capital equipment funding will assist in creating more robust markets for the carpet fibre and backing that will be produced from collection and sorting and for investment in remanufacturing technology.

7 Overseas Examples

7.1 Japan – chemical recycling

Japan disposes of approximately 1 million tonnes of worn clothing every year, with only 12% being recovered in some way. This has prompted the Japanese Ministry of Economy, Trade and Industry (METI) to increase the drive to reduce textiles entering landfill. Voluntary guidelines have been introduced by METI to help establish recycling activities, and funding has been available to improve and develop technologies to recycle fibres. This has resulted in a number of interesting schemes across the country. One of the most successful is the Teijin ECOCIRCLE™.

ECOCIRCLE™ is a closed-loop recycling system for polyester products, which was developed by Japanese company Teijin Fibers Ltd in 2000. Full-scale promotion of the ECOCIRCLE™ system began in 2002 and in October 2008 they enlisted their 100th member to the scheme. Uniforms were selected as the main collection target in the early stage of the programme – probably due to the high level of polyester use in these garments and the ease of collecting uniforms from companies owning larger amounts of similar items rather than from scattered households. Uniforms are still a key product group, as forty of the current ECOCIRCLE™ member companies deal in them.[57]

The ECOCIRCLE™ recycling system requires a number of participants to enable it to be effective. Teijin is at the centre of the system, and besides the production and recycling of ECOCIRCLE™ fibres, they also manage the system and take care of its administration. ECOCIRCLE™ Members' are apparel manufacturers or retail stores that supply products using ECOCIRCLE™ fibres. The end-users of these products are called 'ECOCIRCLE™ Partners'.[58]

Responsibility for collection and sorting of end-of-life ECOCIRCLE™ textiles lies with the ECOCIRCLE™ Members. They are also responsible for organising and financing the deliveries of the ECOCIRCLE™ products back to Teijin's recycling facility in Matsuyama, Japan. In order to ensure the process functions effectively, a labelling system is in place. Each ECOCIRCLE™ product must carry an ECOCIRCLE™ Product Mark along

[57] 100th Member Joins… 2008; Teijin Limited Annual Report 2008, 16.
[58] ECOCIRCLE™ General Operation Rules s.a.; ECOCIRCLE™®: The Meaning… s.a.

with the name and contact details of the ECOCIRCLE™ Member responsible for the product.[59]

Besides those companies manufacturing or supplying uniforms, other ECOCIRCLE™ members are either manufacturers or suppliers of school clothes, interior furnishings, sports and fashion wear, bags and polyester materials. In 2005, Teijin started partnering with American outdoor clothing manufacturer Patagonia to deliver a consumer-facing closed-loop recycling programme. This was the beginning for Patagonia's 'Common Threads Garment Recycling Program'. The first product group that was collected for recycling from Patagonia was Capilene® Performance Baselayers, but Patagonia has widened the programme to cover some other garments as well. In the USA, the end-of-life Capilene® garments are collected at Patagonia's Service Centre in Reno, Nevada and shipped to Japan for recycling. At the moment customers can either post their used garments directly to Reno or leave them at Patagonia's Retail Stores or Performance Baselayer Dealers to be transported to Reno's centre.[60]

Co-operation with Patagonia was an important step in introducing the ECOCIRCLE™ system to wider geographical markets. Currently around 90% of the ECOCIRCLE™ Members are Japanese. Besides expanding international collaboration, Teijin is also looking to secure new members beyond the clothing sector.[61]

7.1.1 The ECOCIRCLE™ Process

Closed-loop polyester recycling enables an end-of-life polyester garment to be turned back into a raw material form that is of similar quality to the original raw material. This is then able to be manufactured into new products.

A chemical process is utilised in the Teijin ECOCIRCLE™ system. However, before chemical recycling processes take place, the ECOCIRCLE™ polyester products are broken down and granulated into small pellets. These pellets are decomposed using chemicals and returned into the raw material (DMT, dimethyl terephthalate) which can then be polymerized again and finally spun into new ECOCIRCLE™ polyester fibres. As zips and buttons are separated during the chemical recycling process, there is no need to remove them beforehand. As well as 100% polyester fabrics, some polyester-rich fabric mixes can be recycled within the system. However at least 80% of a garment's weight must be polyester, which excludes many polyester/cotton mixes. Materials that cannot be used at all include polyurethane, acrylic and

[59] ECOCIRCLE™ General Operation Rules s.a.
[60] Common Threads… s.a.; FAQ s.a.; Patagonia's Common Threads, s.a.
[61] 100th Member Joins… 2008; Teijin Limited Annual Report 2008, 16.

animal materials such as wool or leather. Elastane is also a problematic material for the process.

Environmental Benefits

Teijin has calculated that by replacing the use of virgin material with recycled polyester it is possible to reduce energy consumption by 84% and CO_2 emissions by 77%. To address concerns over the transportation of garments from the USA to Japan, Patagonia calculated the environmental impacts arising from the recycling of used Capilene® garments under the 'Common Threads' scheme. Energy use and CO_2 emissions were calculated for three different scenarios:

A. Teijin's production of polyester from virgin materials
B. Teijin's production of polyester using recycled garments that were locally collected in Japan
C. Teijin's production of polyester using Patagonia's recycled Capilene® garments that were collected in the USA[62]

Table 7.1: Energy use and CO_2 emissions per tonne of DMT produced

Category	Option A Teijin w/out Recycling	Option B Teijin w/Local Recycling	Option C Teijin with Capilene® Recycling	Units
Distance	**	**	7,000	Miles
Fuel for Transport	**	**	38	Gallons
Energy (Production)	72,422	11,962	11,962	Mega Joules
Energy (Transport)	**	**	5,771	Mega Joules
TOTAL ENERGY	**72,422**	**11,962**	**17,733**	**Mega Joules**
CO_2 Emissions (Production)	4.18	0.98	0.98	Metric Tonnes
CO_2 Emissions (Transport)	**	**	0.226	Metric Tonnes
TOTAL CO_2 EMISSIONS	**4.18**	**0.98**	**1.20**	**Metric Tonnes**

*Note: ** These environmental impacts in Option A and B are factored into Teijin's production energy use*

Source: Patagonia's Common Threads Garment Recycling Program: A Detailed Analysis. http://www.patagonia.com/pdf/en_US/common_threads_whitepaper.pdf

The results showed that collecting garments in the USA and transporting them to Japan for closed-loop recycling resulted in a small increase in carbon emissions compared to collection and recycling within Japan.

[62] Patagonia's Common Threads... s.a.

7.1.2 Future possibilities

Many of the corporatewear garments that are currently used in the UK are manufactured using polyester or poly-cotton blended fabrics. Technically, it is possible to use the ECOCIRCLE™ chemical recycling system for many of the polyester rich fabrics that contain at least 80% polyester. However, according to an industry source, compared to the cost of manufacturing polyester from virgin materials, it is about 10–20% more expensive to produce recycled ECOCIRCLE™ polyester. This extra cost is due to higher production costs and investment costs for new systems and machinery. There are also other associated costs such as sorting and transportation that have to be added to the total cost of joining the recycling system. These are likely to be less for applications such as corporate clothing than for general or mixed textiles, despite customer education about the limitations of the process.

7.2 Finland – whole life service

The Finnish textile company Lindström Ltd has an unusual approach to reuse of its workwear products, offering a complete life service. This service includes aspects from design and manufacture to recovery and disposal of the garments. The workwear users, a wide range including industrial and service organisations, have the option to design for reuse initially, and garments are therefore developed to be easy-care, durable and easily repaired. They are then able to be reused a number of times, with detachable logos which can be replaced with new ones at end of service. A particular feature of corporatewear is the frequency of replacement for purely aesthetic reasons (company rebranding, for example), with garments often of high standard and having had little (often no) wear. Lindström offers the choice of reuse to the customer, or the garment can be stored and reused at a later date by a different customer.

By developing reuse into the initial design of apparel, Lindström has managed to overcome a number of issues faced by British corporatewear manufacturers, and clothing can last for many years, across a number of users. Whilst the UK has differences in taxation laws, such that detachable company logos may not currently be an option, preliminary attention to service requirements across varied users – such as numerous washes and assorted environments – can extend product life significantly.

At ultimate end-of-life, when the garment can no longer be utilised, the majority of the textiles are burned at power plants and harnessed as energy, with a small percentage going for reuse as material in lower value functions. This is widely adopted strategy in Scandinavian countries, although less

preferable from a carbon impact perspective compared to recycling (see Section 8 for detailed discussion).

7.3 France – extended producer responsibility

Whilst not necessarily recommended for transfer to the UK, the French scheme for extended producer responsibility for textiles is worthy of note and examination. Articles L.541-10-3 and D.543-214 of the Environment Code allow for the establishment of an organisation, now named EcoTLC, whose responsibility is to encourage the further reuse, recycling and creation of value from used clothing, acting to support the collectors and sorters of textiles. Such support can be used for technological innovation, for market development or for cost reduction, but is aimed at meeting the reuse/recycling commitments of the contributors. It also supports the employment in sorting of difficult-to-employ people. The organisation will work with textile recyclers and local authorities to communicate the value of recycling textiles to the general public. The financial contributors to the scheme are any organisations that place onto the French market new clothing textile products, pairs of shoes or household linen aimed at private households. Taking a whole life cycle approach, reductions of contribution are possible for textile products that have ecolabels.

An overall objective is to sort at least 50% of the textiles that are put on the market by the scheme's contributors. Of this, at least 70% is to be recycled, have value added to it, or contribute to the employment of difficult-to-employ people. This latter category must carry out at least 15% of the additional work brought about by this new legislation. Thus the legislation is motivated by a combination of environmental and social factors.

As part of the establishment of this organisation, research is being carried out into new markets for recycled textiles. One of those that is being marketed in France but not in the UK is thermal insulation products made from recycled fibre. This is described in more detail in Section 8.

In a 2006 Defra report by Oakdene Hollins Ltd[63], producer responsibility schemes were investigated for the UK, and the findings suggested this would not be a suitable scheme for the present situation. This study finds no evidence to warrant a change of stance.

[63] "Recycling of Low Grade Clothing Waste" Oakdene Hollins Ltd, Salvation Army Trading Co. Ltd., Nonwoven Research Institute, Defra WS Project WRT152, 2006

7.4 Germany – design for end-of-life

The German outdoor wear company vauDe has an innovative approach to improving the recyclability of their garments. After much discussion and work with component and fabric suppliers, the Ecolog brand was developed from 100% polyester. All zips, labels, cords, snap fasteners and fabric is created from polyester, making recycling of the garment far more straightforward.

Textile recycling typically involves the process of removing metals and other contaminants. By removing this stage, costs of recycling are reduced and quality of end product tends to be high. Retailers of vauDe clothing are responsible for the return of the garments, which are then granulated by Ecolog GmbH, and turned back into polyester products, including fabric. Whilst not necessarily of the quality required for outdoor apparel, the fabric is suitable for seat covers and office furniture etc.

The UK range of vauDe products tend to be limited to tents, rucksacks and camping accessories, with little apparel sold. A range of pure polyester sleeping bags was launched in previous years, but the demand was low and the range was discontinued. The UK market was perceived to have little focus on environmental credentials at the time.

7.5 USA – carpet recycling initiative

The USA has CARE (Carpet America Recovery Effort), an organisation managed and funded by the carpet and rug manufacturers. It is backed by the Carpet and Rug Institute (CRI) and various national and federal government agencies. It also has a wide membership of companies that specifically deal with carpet recycling and it encourages the development of new recycling technologies. CARE is extremely focused on recycling issues and develops future targets for carpet and rug recycling through a stage of negotiation with various stakeholders. Although their ambitious targets through the period 2002 to 2007 have not been met, the growth in carpet diversion from landfill has been impressive. Because most of carpet produced in the US stems from Georgia, CARE has been able to bring together the majority of producers with a common aim of "Carpet Stewardship". The information that it provides to the general public and the world at large is thorough and open, thus allowing others to follow their example.

In the UK, the organisation Carpet Recycling UK was set up to follow the CARE model. CARE recognises Carpet Recycling UK as the equivalent operation in the UK and is working closely with the organisation to share experiences and successes. Carpet Recycling UK does play a significant role

in encouraging carpet recycling but probably due to financial and industry/government support restraints is limited in what it can achieve.

In January 2001, in recognition of the vast amount of carpet being disposed of to landfill in the USA (approximately 2,000,000 tonnes per year), the Carpet and Rug Institute (CRI) together with the Minnesota Office of Environmental Assistance signed a Memorandum of Understanding (MOU) for manufacturers and Government to:

- negotiate a schedule for the eventual elimination of carpet and rug disposal to landfill and incineration and establish reuse and recycling targets
- encourage the carpet industry to establish a third party organisation that would be responsible for achieving the negotiated schedule of recycling and reuse
- establish procurement guidelines for public entities to adopt.

After a two year negotiation process between the carpet industries, representatives of government agencies at the federal, state and local levels, and non-government organisations, a further MOU[64] was signed in January 2002 which established the National Agreement on Carpet Recycling. This agreement set out a plan to change how carpet was managed in the USA and consisted of the following aims:

- A landfill diversion goal of 40% to be achieved by 2012
- A voluntary agreement between the carpet industry, state governments, the US Environmental Protection Agency, and non-governmental organizations (NGOs)
- To promote product stewardship by asking manufacturers to assume responsibility for funding the overall effort and meeting the goals for recycling and reuse
- To overcome barriers to recycling and reuse of post-consumer carpet and to develop systems that treat discarded carpet as a resource instead of waste
- To establish a "third party organisation" funded by the carpet industry and responsible for meeting the negotiated national recycling targets
- To negotiate a new 10 year plan in 2010.

Table 7.2 shows the negotiated targets agreed in 2002 (values from the original table have been converted from pounds weight to tonnes)

[64] http://www.carpetrecovery.org/pdf/CARE_MOU/MOU-January%202002.pdf

Table 7.2: Negotiated 2002 targets

	2002	2003	2004	2005	2006
	Tonnes				
Total Discards	2,121,905	2,189,944	2,059,949	2,285,199	2,386,350
Reuse				11,340	
Recycling	180			160,118	
W2E		21,772	20,412	22,280	24,040
Cement Kilns				45,359	
Landfill	2,040,259			2,045,702	
Recycling Rate	3.8%			7%	
Landfill Diversion Rate	3.8%			10%	
Original data was presented in pounds weight but has been converted to tonnes					

Table 7.2 continued.

	2007	2008	2009	20010	2011	2012
	Tonnes					
Total Discards	2,535,582	2,559,168	2,670,298	2,730,626	2,995,978	3,071,728
Reuse		51,256		95,708		92,079-153,768
Recycling		281,227		409,594		614,164-769,932
W2E	25,401	25,401	26,762	27,216	29,937	30,844
Cement Kilns		136,078		90,718		90,718
Landfill		2,064,753		2,107,390		2,182,687
Recycling Rate		11%		15%		20-25%
Landfill Diversion Rate		19%		23%		27-34%
Original data was presented in pounds weight but has been converted to tonnes						

Source: 2007 Annual Report – Carpet America Recovery Effort

The MOU established the organisation CARE[65] (Carpet America Recovery Effort) as the third party organisation. The group, with members from the

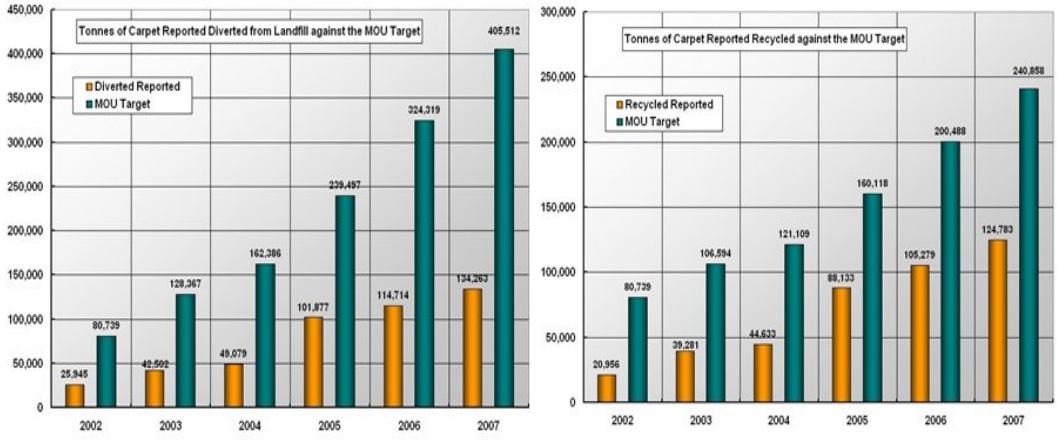
[65] http://www.carpetrecovery.org/index.php

carpet industry and government is funded and administered by the carpet industry and is responsible for monitoring, evaluating and assessing progress toward the Negotiated Outcome Goals. This national agreement on carpet recycling is a voluntary agreement between the carpet industry, state governments, the US Environmental Protection Agency, and non-governmental organizations (NGOs).

CARE's mission is to *"find market driven solutions to the diversion of post-consumer carpet from landfills to meet the time sensitive goals of the Memorandum of Understanding (MOU) for Carpet Stewardship"*.

The organization has a total of 55 facilities actively accepting and processing post-consumer carpet waste for recycling and reuse, and most US carpet manufacturers achieve zero-to-landfill targets each year which has been enabled by the development of an extensive collection and processing network of companies and the development of end markets for the products. Since its inception in 2002, CARE has reported a total approaching 470,000 tonnes of carpet that have been diverted from landfill. However, from the recent 2007 annual report[66], it is clear that the target of 40% diversion from landfill by 2012 will not be achieved. The following figure shows the progress in recycling and total landfill diversion between 2002 and 2007.

Figure 7.1: MOU carpet diversion from landfill and recycling tonnages against targets



The report clearly defines recycled as all materials recovered and recycled by being re-manufactured into the same or different products or by being used as feedstock in a manufacturing process, whilst diverted is defined as recycled plus material sent to waste-to-energy facilities or cement kilns.

[66] http://www.carpetrecovery.org/pdf/annual_report/07_CARE-annual-rpt.pdf

CARE has also produced a number of procurement documents for products containing post-consumer carpet to help stimulate the market for these end products. Companies identified as providing products from recycled carpets include:

- **GeoHay**[67] - a portfolio of barrier filtration products which aid the control of soil erosion and sedimentation run-off. Produced from 100% recycled carpet fibres the products have been shown to be more effective than other products, including natural hay bales[68]. At the end-of-life GeoHay will take back the product and remanufacture it.
- **INVISTA**[69] - Antron® EcoSoft® Carpet Cushion
- **Carpet-Burns Ltd**[70] - surface coverings, panelling and backerboards
- **Infiltrator Systems Inc**[71] – Chambers for septic and storm water management
- **I-Rock Composites** - Sound barriers and landscape wall systems
- **Nycong**[72] – Concrete, asphalt and plastic
- **Los Angeles Fibre Co**[73]. – Carpet cushion products
- **Wellman Inc**[74] – Automotive parts.

According to the CRI's Sustainability Annual Report for 2008[75], the carpet industry produces nearly 1,800 million m^2 of carpet each year with almost 90% of this carpet being manufactured in Georgia. The data used by the CRI comes from 83 production facilities and approximately 90% of the 113 CRI members.

[67] http://www.geohay.com
[68] http://www.geohay.com/documents/evaluation_of_peformance.pdf
[69] http://antron.net/
[70] http://www.carpet-burns.com/
[71] http://www.infiltratorsystems.com/
[72] http://www.nycon.com/NyconG.htm
[73] http://www.lafiber.com/
[74] http://www.wellmaninc.com/
[75] http://www.carpet-rug.org/commercial-customers/green-building-and-the-environment/recycle-recover-and-reuse.cfm

8 Barriers and Opportunities for Recycling

Whilst the waste hierarchy indicates reuse as the preferable end-of-life management option to recycling, energy recovery or disposal, this is not always feasible for all textiles. Logistics sometimes result in other routes being more suitable. Reuse overseas involves transportation costs, and frequently, when sorting does not occur before export, lower grade textiles can be transported out of the UK only to be transported back in, once the 'cream' of the textiles have been removed. UK sorting therefore gives a better environmental profile, as well as giving economic resilience if overseas markets become temporarily closed, as has happened with other recyclates recently. In order to stimulate this, stronger UK markets for recycling grade textiles are needed.

The total of available recycled textiles in 2008 was 27,000 tonnes. Much of this material was mechanically recycled into fibre for mattresses and upholstery, carpet underlay and products for the automotive industry such as acoustic damping, panelling and interior upholstery. A smaller amount of this available recycled fibre was used for the manufacture of a range of diverse products such as horticultural basket liners, capillary matting, and thermal insulation. These traditional markets for recycled textiles are mature and are perceived to offer very little opportunity for added-value by textile recyclers.

Table 8.1: Available recycled textiles in the UK

Recycled Grade Source	2008 tonnes
Recycled in UK	10,000
UK Exported for Processing and Returned to UK	7,000
Non-UK Sourced	10,000
Total	**27,000**

Source: This study (see Section 4.5)

There has been a decline in the recycling of fibre within the UK since a previous study in 2006, and almost certainly before this date as well.. This has largely been attributed to the greater attractiveness of virgin natural and manmade fibres in textiles due to attributes associated with the appearance of recycled fabrics. As regards flocking in mattress applications, it is increasingly difficult to source wool-rich UK product as sorting moves abroad and as the wool content of textiles declines.

Downcycling of textiles to lower value products typically needs less stringent physical, mechanical and compositional property requirements placed on those recyclate fibres that are specified for higher value products. As was mentioned in the Oakdene Hollins 2006 report, innovation in the textile recycling sector is almost absent. Work that was carried out by the Nonwovens Innovation & Research Institute Ltd[76] (NIRI) examining new technologies to add value to recycled material has made little progress. Work is still continuing but in general the research and development cycle and the uptake of new technology is longer term.

Recycling of textiles to higher value applications is likely to require the minimisation or avoidance of fibre blends, and increasing use of single fibre types in textiles. The advantages of such approaches at the end of first life has to be balanced against possibly perverse impacts at other lifecycle stages, as well as technical performance and customer acceptability.

[76] http://www.nonwovens-innovation.com/

One of the issues that continues to be a barrier to developing added-value technologies from recycled textiles is the low quality and variation in quality of feedstock. In general, the available stock is in the form of mixed fibre and this limits the engineering of new materials because of variability in physical and mechanical properties. It is believed that more research should be directed further upstream at the mechanical or chemical separation stage. However, this requires significant capital investment and without the clear demonstration of added-value technologies and product demonstrators, there is little chance of this investment happening. A further point made is that a more holistic approach should be taken whereby the textile manufacturers should be examining ways of producing fabrics and garments which have inherent capacity for disassembly. This would then allow fibre separation to be achieved with lower cost investment.

A substantial problem encountered in developing new high added value technologies for waste textiles is the availability and sourcing of well specified fibre. Although many recyclers of textiles would invest in more advanced equipment to process waste textiles into higher added value fibre, the market for products using these materials is still not well established.

8.1 Design for Disassembly

One way to prolong the life of clothing, is designing for disassembly, allowing for replacement of worn or damaged sections. The Centre for Remanufacture and Reuse (CRR) carried out trials in 2009 as part of a Uniform Reuse[77] project for the Defra Sustainable Clothing Roadmap. This investigated new bonding methods using adhesives in place of stitches to join seams. If a sleeve or panel was then damaged, a reverse manufacture heating process allowed for the components to be disassembled without any damage or loss of strength as may occur in de-stitching.

The trials were run by Sally Cowan Ltd, and were successful for demanufacture, with the adhesive also working to bond more effectively than stitches for five of six fabrics trialled. The disassembling process is costly however, and this technology would be most appropriate for use in high value garments where appearance is not critical. Possible candidates might be personal protective equipment used by fire-fighters.

8.2 Mechanical recycling of fabrics and clothing

Textiles which recyclers consider too damaged or of too low quality for reuse will end up in the waste stream as either wipers of various grades which

[77] http://www.uniformreuse.co.uk/pdf/alternative_joining_methods.pdf

require little processing technology or are broken down further into a mixture of their constituent fibres. A large proportion of these fibres will end up as reconstituted yarns or as feedstock for nonwoven products.

8.2.1 Textile to fabric

Upcycling of certain hardwearing textiles into alternative products is carried out in the UK, although the volumes are low. Examples include converting old seat coverings into bags and shoes.

8.2.2 Textiles to yarn

Yarns produced from end-of-life post-consumer textile waste show different characteristics to those of the virgin yarns. These yarns are usually of mixed colour and of variable fibre length with poorer physical and mechanical properties. Fabrics made from such yarn (shoddy and mungo) were widely manufactured in the UK during the industrial revolution. Today, however, their production is limited to certain developing countries such as India and Morocco. In the UK, any yarn produced from recycled textiles is generally not used for the re-creation of new garments or household textiles but is diverted to the production of synthetic technical textiles. Even so, new technical textiles produced from recycled fibre still require a proportion of virgin fibre (10-15%) to be added in order to achieve the minimum properties required for processing. Products manufactured using these yarns would be, for example, woven filtration systems and geotextiles (permeable woven or non-woven fabrics used as an integral part of a structure or system of foundation, soil, rock or similar). In the case of some applications, for example geotextiles, only fibre produced from pre-consumer waste would be acceptable in Europe[78]. A well defined textile waste stream would need to be provided for this type of application.

8.2.3 Textiles to fibre

A greater proportion of the fibre reclaimed from textiles will be used in the manufacture of nonwoven products.

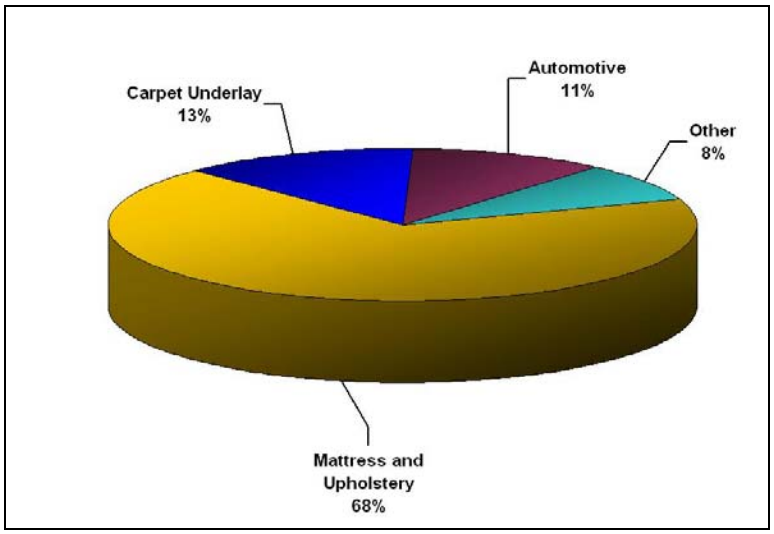
World production in 2004 was estimated to be 4.4 million tonnes rising to 6.3 million tonnes in 2009. According to the market share data, Western Europe was producing 1.36 million tonnes of nonwoven product and this was predicted to increase to 1.76 million tonnes even though there will be a decrease in market share.

[78] Geotextiles in Europe must conform to the European Standard EN 13249 "Geotextiles and geotextile-related products – Characteristics required for use in the construction of roads and other trafficked areas (excluding railways and asphalt inclusion)" where it states that the product "contains no post-consumer waste"

Although the availability of recycled fibre for the UK market has reduced from 34,000.tonnes to 27,000 tonnes, the market is still dominated by three main application areas consuming approximately 86% of this tonnage

The largest volume production in the UK is for mattress/upholstery with approximately 66% of all recycled product being in this market. Carpet underlay and automotive applications (mainly sound insulation materials) are much lower volume markets (11% and 8.7% respectively). There are also many other much smaller diverse application areas that comprise almost one sixth of the total market, including horticultural basket liners, capillary matting, and thermal insulation. The market is summarised in Figure 8.1.

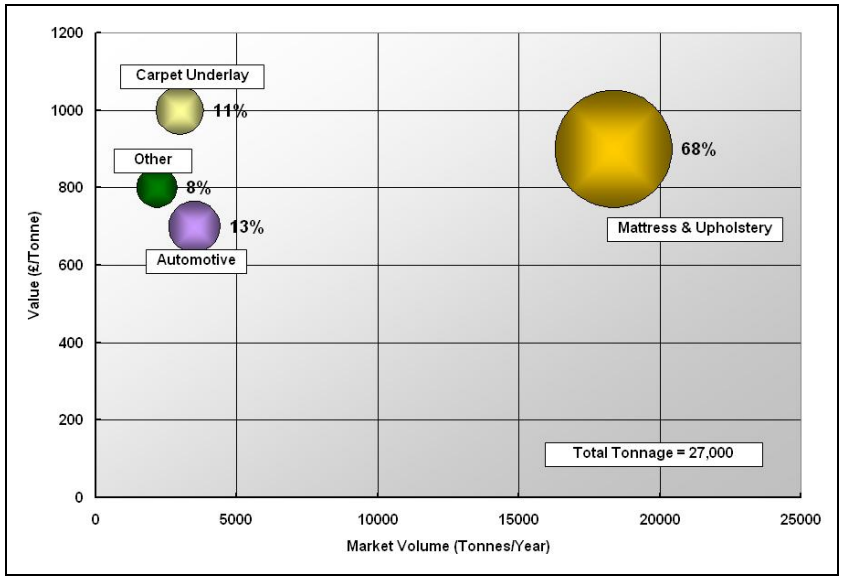
Figure 8.1: Market for recycled textiles as nonwovens (approximate total 27,000 tonnes in 2007)



Source: Industry contacts

The applications for nonwoven products are diverse. The majority are high-volume, low added-value. It is into these products that most of the recycled fibre from textiles enters (Figure 8.2).

Figure 8.2: Low added value products from recycled fibre

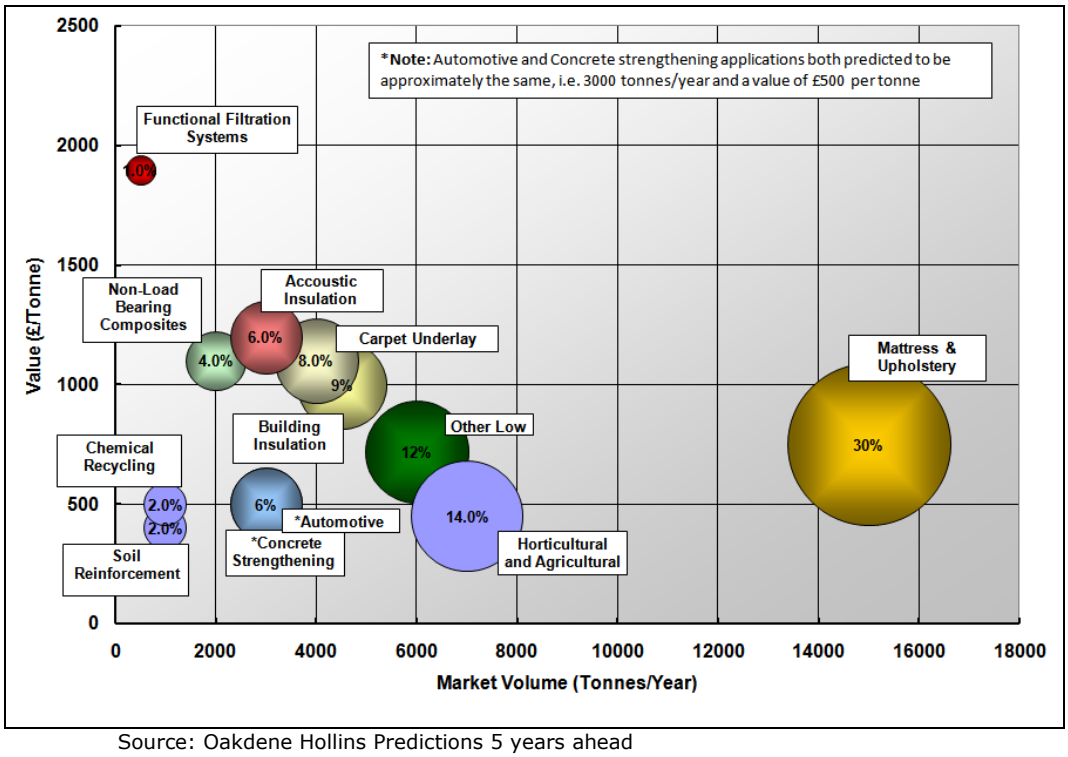


Source: Industry contacts

This is essentially downcycling of the fibre recyclate from textiles. Small proportions of the recycled textiles enter the higher added value chain or are

upcycled. In these circumstances, the recyclate fibres are usually well characterized and usually from a single type of fibre depending upon the application. There is also the opportunity to redirect fibre into further added value products. However, technology advancement has been slow and there has been little evidence of change since the last report.

Figure 8.3: Five year forecast for new market applications



Source: Oakdene Hollins Predictions 5 years ahead

Assumptions based upon:

- recycled textiles available increases to 30,000 tonnes due to modest intervention to stimulate market development
- 20,000 tonnes of carpet are recycled
- modest increases in energy and raw material cost from April 2009.

Typical applications for general nonwoven products are as follows:

- disposable diapers
- sanitary napkins & tampons
- sterile wraps, caps, gowns, masks and drapings used in the medical field
- household and personal wipes
- laundry aids (fabric dryer-sheets)
- apparel interlining
- carpeting and upholstery fabrics, padding and backing
- wall coverings
- agricultural coverings and seed strips

- automotive headliners and upholstery
- filters
- envelopes
- tags
- labels
- insulation (both thermal and acoustic)
- house wraps (a form of insulation that is placed on the surface of the brickwork prior to the final brick surface layer)
- roofing products (felts etc)
- civil engineering fabrics/geotextiles
- composites, e.g. polymer matrix with recycled textile reinforcement used in automotive applications and also in non-load-bearing decorative structures.

8.2.4 Opportunities and barriers to new products from recycled textiles

There are numerous opportunities for developing new applications for recycled textiles. A number of these are shown below but are certainly not exhaustive.

Textile Fibre Reinforced Concrete

Concrete is the most commonly used construction material in the world. Although it has excellent properties in compression it is generally weak in tension, has low ductility and low energy absorption. There have been many studies that have examined ways of improving the tensile properties of this material which have usually involved the addition of small quantities of fibres (0.2 to 2% by volume). Some of the fibres which are used include steel, carbon, nylon and polypropylene. The key to using fibres for reinforcement is to ensure that they do not react with the concrete mix either during mixing or during service. Some studies have shown that polypropylene and nylon, which are the major constituents of carpet and rug, are not degraded by the alkalinity of Portland cement[79]. This makes them eminently suitable for the reinforcement fibre for concrete. On the other hand, polyesters do show excessive degradation in cement. Fibre dimension is critical in this application, and it is in the USA that longer fibre, which is more applicable to concrete reinforcement, is generally used in carpet manufacture. Carpet fibre in the UK is somewhat shorter, which could limit this possible application for recycled carpet.

An example of the use of carpet waste fibres was in the full scale construction of the R&D Centre of Shaw Industries Inc in Dalton Georgia. In this instance 20 tonnes of pre-consumer waste carpet was used with a dosage of about

[79] Groom J.L., Holmquist D.V. and Yarbrough K.Y. (1993), Use of waste nylon fibres in Portland cement concrete to reduce plastic shrinkage", in Proc. Recovery & Effective Reuse of Discarded Materials and By-Products for Construction of Highway Facilities, Denver, CO, Oct. 19-22, pp 179-183.

6kg/m^2. This project showed the feasibility of using waste fibres for concrete construction.

Barriers	Opportunities & Benefits
Post-industrial waste is more appropriate as post-consumer carpet requires cleaning and separating. Only applicable to waste polypropylene and nylon fibre. Specification and construction standards precluding such additions.	High volume, although low added value. Concrete structures are generally long lasting and can be recycled for hardcore.

Soil Reinforcement

Geotextile fabrics have long been used for soil reinforcement during road construction. It is also known that short fibres added to soils have a positive effect, enabling the soil to have greater cohesion properties. There have been successful examples of the use of virgin polypropylene and glass to reinforce soil and sand[80].

Barriers	Opportunities & Benefits
Certain standards throughout the world will not allow the use of post-consumer waste product to be used in geotextiles applications.	High volume, low added value. Any waste carpet product fibre can be used. Trials have shown that shredded carpet waste can be blended into soil with conventional equipment.

Non-Load Bearing Composites

The Nonwovens Innovation & Research Institute (NIRI) has investigated the use of recycled textile waste as a replacement for glass fibre in glass reinforced plastics (GRP). From their initial work using a web of recycled polyester/cotton and a needlepunched acrylic fabric together with an epoxy resin they were able to show the final composites to be strong, light and relatively stiff and suitable for non-load bearing composite applications.

Barriers	Opportunities & Benefits
Lack of investment in R&D. Glass fibre reinforcement still competitive on cost.	Possibly cost-effective in markets where mechanical and physical properties not as stringent as for load-bearing composites.

[80] Crockford W.W., Grogan W.P. and Chill D.S. (1993), "Strength and Life of Stabilised Pavement Layers Containing Fibrillated Polypropylene", 72nd Annual Meeting of the Transportation Research Board, Paper 930888, Washington, D.C.

Filtration Systems

Recycled textiles used to produce nonwoven structures should be eminently suitable for the production of filtration systems. With a high surface area the fibres can be surface treated with specific functional chemicals. For example, it has been shown that treating a recycled wool nonwoven with chitosan together with a low temperature plasma treatment will produce a filtration system that effectively removes toxic Pb^{2+} ions from waste streams. Chitosan is also very effective in removing phosphorus and surface oils from water[81]. From an industry source there have also been attempts to impregnate nonwoven fabrics produced from recycled fibre with ion exchange materials thus extending the functionality and added value of the material.

Barriers	Opportunities & Benefits
The market is price sensitive and only lower value products would be acceptable, unless functionality could be improved.	Easily adapted nonwoven structures are possible. A wide variety of products could be developed.

Acoustic Insulation

Work has been carried out by Mohsen et al[82] that looked into the manufacturing methods and effects of variation in grain/fibre ratio, binder concentration and particle size on the impact transmission performance of a range of laboratory-produced underlays manufactured from recycled carpet tiles. From this work it was concluded that it is possible to produce and develop acoustic underlay from PVC-backed, nylon or polypropylene carpet tile wastes that were superior to conventional acoustic underlay products. This technology would allow the replacement of virgin fibre in a number of other noise control applications, for example, traffic noise abatement, automotive and buildings.

Barriers	Opportunities & Benefits
Granulation of PVC product	Less reliance on virgin fibres. Reasonably large market.

Building Insulation

The French textile recycler Le Relais[83] collects 45,000 tonnes of used textiles each year and claims to be the largest textile recycler in France. The company has developed a thermal insulation product called Métisse®. The product consists of 70% cotton and 15% wool and acrylic with 15% polyester added as a binder. The material is treated for fungal protection and is insect repellent. The insulation material has a thermal performance comparable to mineral

[81] Radetic M., et al (2003) "Application of recycled wool based nonwoven material for purification and cleaning of waters" 9th Aachen Textile Conference, Aachen D 27-28 Nov., DWI Reports 126 pp 274-283.

[82] M. Miraftab., I. Rushforth, K Horoshenkov and M Swift "Recycling carpet waste into acoustic underlay for commercial production", Project PLA4-012, March 2004, WRAP.

[83] http://www.lerelais.org/Isolant-Metisse

and glass fibre and can absorb and release moisture. It is provided in 8 x 0.6 metre lengths and 5 to 20 cm thickness and is claimed to be best suited to timber-framed structures. It is used as loft, roof and wall insulation. The product was launched in the UK in March 2007 and is currently being marketed by the UK Building Merchant Ecomerchant Ltd.

Barriers	Opportunities & Benefits
Requires the continuous availability of recyclate.	Already being marketed throughout Europe. Simple process. Many thermal insulation opportunities in the building sector. Products manufactured using recycled textiles do not require safety equipment when installing.

A number of other applications were explored and reported by NIRI in the 2006 report and include:

- added functionality automotive products
- phase change materials
- heat retention composites using silica aerogels
- odour control fabrics
- nonwoven structures to behave like Zeolites
- biocomposites.

At this point in time there has been no major advance in these technology areas. It is clear that with further innovation and investment there will be more opportunities for developing new products from recycled textiles into existing and new markets.

Horticultural Matting

Horticultural matting is produced by a number of UK manufacturers. A variety of fibres may be used, including cellulosics and wool. Suitable applications include agricultural matting, capillary matting for horticulture and in certain green roof systems.

Barriers	Opportunities & Benefits
Risk assessment for human health and environmental impact. Specification within green roof system Low cost of many existing systems.	Potentially large volume. Existing market for certain recycled textiles. Potential to improve performance and added value to recycled textiles.

8.3 Composting

8.3.1 Best practice and definition of composting

Increasingly, textile manufacturers are developing new products that either totally or partly contain biodegradable fibre. These biodegradable fibres can be obtained from synthetically manufactured polymers such as, polylactic acid (PLA), polyhydroxyalkanoates (PHA) and polycaprolactone (PCA), or from natural animal products such as wool, or from bast products such as cotton, flax, hemp jute and ramie, or from polyesters produced from microorganisms. Each type of fibre has various degrees of biodegradability and in some circumstances is not suitable for domestic composting. The terms biodegradability and compostability are sometimes used by manufacturers to infer the same thing. It is important to recognise and even distinguish the difference.

The Association for Organics Recycling (AFOR), formerly The Composting Association (TCA), defines composting as[84]:

"the process of controlled biological decomposition of biodegradable materials under managed conditions that are predominantly aerobic and allow the development of thermophilic temperatures as a result of biologically produced heat"

and compost as:

"a solid particulate material that is the result of composting, that has been sanitised and stabilised and that confers beneficial effects when added to soil, used as a component of a growing material or is used in another way in conjunction with plants."

The standard for compliance has been published by the British Standards Institution (BSI PAS 100).

The European Standard EN13432 "Requirements for packaging recoverable through composting and biodegradation - Testing scheme and evaluation criteria for the final acceptance of packaging" defines the characteristics that a material must have, in order to be defined as "compostable". This standard is equivalent to the US Standard ASTM D6400 with only minor differences. These will equally apply to textiles as they do to packaging materials.

According to the European Standard EN13432, which has been published in the Official Gazette of the European Union and adopted by all member states, a compostable material must have the following characteristics:

[84] "The Composting Industry Code of Practice"

- It must be biodegradable and quantitatively measured using the standard test method EN14046 (which is also published as ISO 14855: biodegradability under controlled composting conditions). To be acceptable as biodegradable it must reach 90% within 6 months.
- It must disintegrate according to the composting test method EN14045. This method requires that the material be composted with organic material and after a period of three months there should be less than 10% of the sieved composted material with a dimension higher than 2 mm.
- It must not contain heavy metals above the maximum values stipulated nor have any negative effects on the quality of the compost. A plant growth test according to OECD Test 208 (modified) is also carried out to show any differences to that of a control compost. Other factors such as pH, salinity, volatile solids, nitrogen, phosphorous, magnesium and potassium are required to be the same as the control compost.

To be "compostable" the material must satisfy ALL of the above criteria. A material can therefore be claimed "biodegradable" but not necessarily "compostable".

In the UK the Association for Organics Recycling (AFOR) operates a PAS 100 and Quality Compost Protocol Certification Scheme managed by the competent bodies NSF-CMi Certification and Organic Farmers & Growers Ltd. The scheme enables certification to the DIN V 54900, BS EN 13432 and ASTM D 6400 standards. In Germany the certification body is Din Certico which operates the European Compostability Mark.

8.3.2 Review of existing compostable fabrics

Clearly there is an advantage in designing and manufacturing textiles which can be easily composted at end-of-life thus providing a means of generating added value by-products rather than disposal to landfill. A number of companies are actively involved in developing technology that will eventually minimise the impact of used textiles on the environment.

Climatex® [85], which is produced in Switzerland by Rohner Textil AG now acquired by Gessner AG, is a textile consisting of three fibre types, namely pure wool, polyester and ramie. It has been designed essentially as an upholstery fabric for climate control seating and attains its properties from the individual characteristics of each of the fibre types. Although the textile is not manufactured from recycled fibre, it has been shown to be fully biodegradable and therefore compostable. Waste material from the manufacturing process can be used in nonwoven products but can also be used as gardening mulch. Further research by the company to develop

[85] http://www.climatex.com/en/products/products_overview.html

elasticity in the textile demanded changes in manufacturing technique rather than using other conventional non-compostable synthetic fibres such as elastane.

Interface Fabrics Group[86] (IFG) has produced a family of textiles based on their Terratex® product. This is a fabric which is made from 100% recycled material including post-industrial and post-consumer waste including recycled PET and wool. Herman Miller[87] has worked closely with IFG and Cargill Dow to develop a fabric called KIRA.

This fabric is based on the polymer polylactic acid (PLA) which Cargill Dow[88] makes from corn sugar. They then spin the resulting PLA fibre into Ingeo® Fiber. Ingeo® Fiber is a product marketed globally by NatureWorks[89] LLC which is joint venture between Cargill Dow and Teijin Limited[90] of Japan established in December 2007. IFG then weaves the fibre into the yarn it uses to produce KIRA.

DesignTex introduced a new range of upholstery fabrics based upon Climatex® Lifecycle™ in 1999. Carnegie[91] offers a range of compostable fabrics which include Terratex® and Climatex®.

In the current situation, no recommendations are made to increase the investment in creating compostable fabrics.

Barriers	Opportunities & Benefits
Most compostable fabrics unlikely to be suitable for municipal UK composting facilities. Environmental benefits versus recycling are not quantified. Confusion between compostable and recyclable products by consumers.	Potential environmental benefit at end of life. Company-led collection schemes likely to be the most practical.

[86] www.interfacefabricsgroup.com
[87] http://www.hmeurope.com/
[88] http://www.cargill.com/
[89] http://www.natureworksllc.com/
[90] http://www.teijin.co.jp/english
[91] www.carnegiefabrics.com/

8.4 Chemical recycling of post-consumer textiles

Polyester

Interest is growing in the use of chemical recycling as a method of recovering valuable polyester materials from textiles.

Asahi Kasei Fibers has launched a product called ECOSENSOR™. The material is made from polyester fibres chemically recovered from recycled polyester textiles and PET films and bottles. The process breaks down the polymers of the used polyester products to their two constituent monomers, and then separates, purifies and polymerizes the monomers to produce pure polyester polymer. Applications suggested include innerwear, outerwear, work uniforms, components, linings and sportswear.

Cellulosics

Research is also being carried out into the use of ionic fluids for recycling cellulosic materials. Ionic liquids (IL) are new direct-dissolving systems for cellulose characterized by unique dissolving properties and simple technical handling. Selected IL-systems are non-toxic and chemically as well as physically neutral which represents an advantage as compared to the commonly used direct solvent N-methyl - morpholine-N-oxide (NMMO). Fibres can easily be prepared by coagulation in water. BASF now have an exclusive licence[92] on the use of ionic liquids to dissolve cellulose. The Teijin ECOCIRCLE™ process has been described previously. Around 100 companies participate in the scheme, largely Japanese uniform companies.

In general, however, ionic fluids are expensive and require correct handling and recycling operations. BASF claims to be able to recycle the ILs up to 98%. Use of ILs is largely oriented towards production of fine chemicals. Use of ILs to dissolve cotton and then to re-extrude cellulosic fibres appears possible but is at the research stage only.

Alternative chemical recycling for cellulosic textiles using pulping technology to produce precursors to a lyocell fibre is under consideration by a research consortium. This would potentially provide a clothing-to-clothing route albeit from cotton to lyocell.

Barriers	Opportunities & Benefits
Cost. Selectivity of processes. Sorting costs.	Closed loop recycling possible. Substantial reduction in certain impacts possible. Attractive to end users

[92] from Rogers et al , Alabama , WO 2003 029329, JACS 2002, 124,4974

8.5 Textile recycling (carpet and rug)

8.5.1 Carpet recycling initiatives in the UK and Europe

In the UK a new organisation, Carpet Recycling UK, has recently been established using the CARE model in the USA. Set up as a not-for-profit membership organisation in November 2007, the fundamental aim of Carpet Recycling UK is to accelerate carpet recycling activities in the UK using best environmental technologies. Specifically, the organisation aims to:

- encourage a competitive recycling industry within which highest environmental value technologies are supported
- stimulate end markets for carpet recyclates through technical research and promotion to key industrial sectors
- address technical problems in the recycling of carpet waste
- expand the variety of collection channels and take-back logistics.

Carpet Recycling UK is an industry-driven effort, backed by manufacturers, distributors and retailers, to reduce the impact of carpet at end of life and develop end markets through technical research development projects[93]. Local Authority waste contractors have signalled a desire to aid in the collection, storage and delivery of waste carpets and will pay recycling companies the equivalent cost of landfill for their end-of-life carpets.

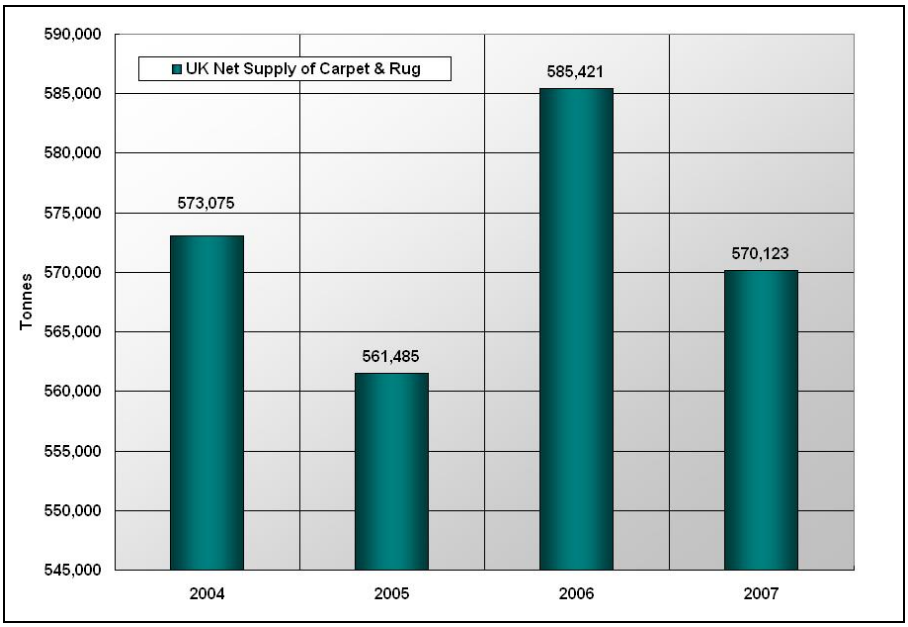
One project has already begun, based around the South Wales region, which is working with a number of partners including an OEM and building contractors to uplift carpet tiles for refurbishment. These will then be resold back into the construction market with a warranty to match that of a new product. The first phase of the project is a feasibility assessment of the scheme which, if considered workable, will then lead to the production of a business plan.

Using data provided by the Office of National Statistics[94], the following net supply of carpet and rug to the UK is shown in Figure 8.4 below. Data from ONS are provided in square metres and an estimate of the average weight of 2.22 kg / m^2 has been used to determine the approximate tonnage of carpet and rug.

The types of carpet manufactured or supplied into the UK over the period 2004-2007 according to ONS statistics have not changed significantly and are shown in the following chart, Figure 8.5.

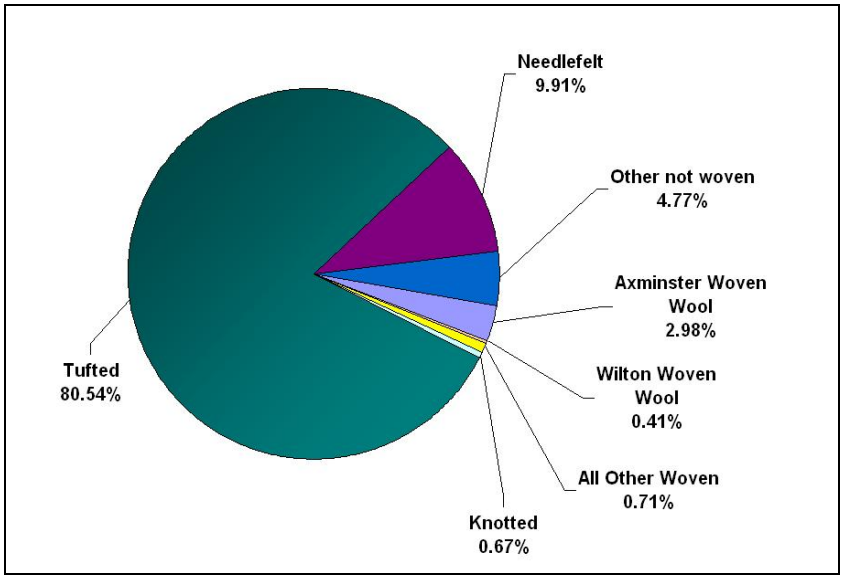
[93] Personal communication with Carpet Recycling UK
[94] http://www.statistics.gov.uk/downloads/theme_commerce/PRA-20070/PRA17510_20070.pdf

Figure 8.4: Tonnage of carpet and rug supplied into the UK market, 2004 - 2007



Source Data: Office of National Statistics

Figure 8.5: Types of carpet and rug supplied to the UK market, 2004 - 2007



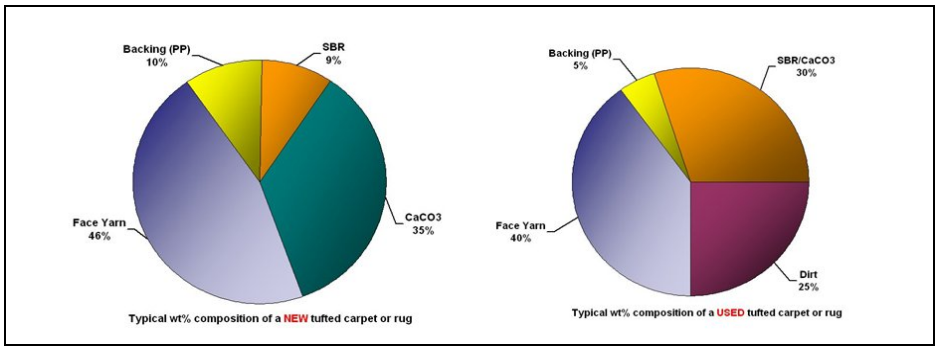
Source Data: Office of National Statistics

Over 80% of the carpet and rug supplied into the UK market is tufted. Tufted carpet has been the predominant carpet type since the late 1970s.

We can assume that each year new carpet is replaced for old and therefore on average 550,000 tonnes of carpet and rug are disposed of each year. In most

cases a typical tufted carpet consists of the yarn and two layers of mostly polypropylene (PP) backing between which there is a calcium carbonate-filled, styrene-butadiene latex rubber (SBR). The approximate weight proportions of each material[95] are shown in Figure 8.6. The yarn, which makes up for approximately 46% by weight of a new carpet can be from a selection of synthetic fibres such as Nylon 6, Nylon 6,6 (both referred to as Polyamides), Polypropylene (polyolefin), and polyester or a mixture of these with wool. The wool content of carpet yarn is generally far less than 20% but the largest volume of commercial and domestic carpet uses synthetic yarns. The proportion by weight of each of the synthetic fibres used is shown in Figure 8.6. It is noticeable that post-consumer waste contains a significant quantity of dirt which must be removed before any recycling of the remaining materials is considered. It is estimated that up to 1kg of dirt can be collected from 1m² of end-of-life carpet[96]. As well as being a time consuming process, cleaning also uses large quantities of water and detergents. Recycling processes that do not require pre-treatment of end-of-life carpets are therefore considered preferential in terms of environmental impact.

Figure 8.6: Weight % of materials which make up a new and used tufted carpet or rug

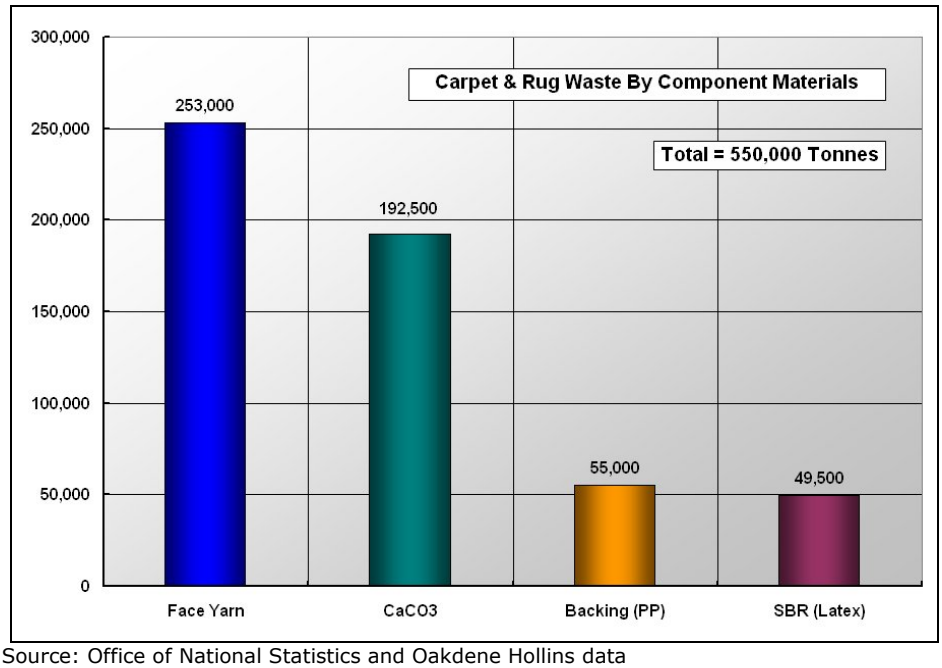


Source: Y Wang, Recycling in Textiles, Woodhead Publishing, 2006

On the basis of these figures, it can be estimated that approximately 253,000 tonnes of yarn, 192,500 tonnes of $CaCO_3$, 55,000 tonnes of polypropylene backing and 49,500 tonnes of SBR are available for recycling each year (Figure 8.7).

[95] Braun M., Levy A.B. and Sifniades S., (1999), "Recycling Nylon 6 Carpet to Caprolactam" Polymer-Plastics Technology & Engineering, Vol 38, No.3, 471-484.
[96] Personal communication with Burmatex

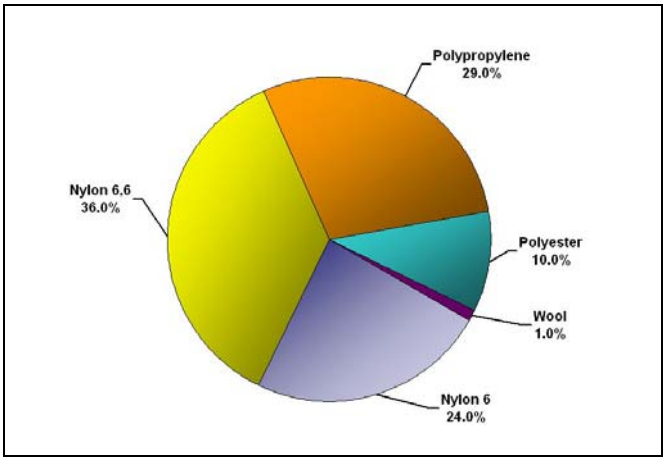
Figure 8.7: Tonnage of component materials available for recycling from carpet and rug each year



Source: Office of National Statistics and Oakdene Hollins data

As SBR is a thermoset material and cannot be remelted or reshaped, this component of the carpet has found little use in recycling and is therefore usually disposed to landfill. However, several research institutes and companies around the world are working on methods to recycle thermosets down to their chemical units with ionic liquids. The breakdown in terms of percentage types of yarn used in a typical carpet are shown in Figure 8.8 below.

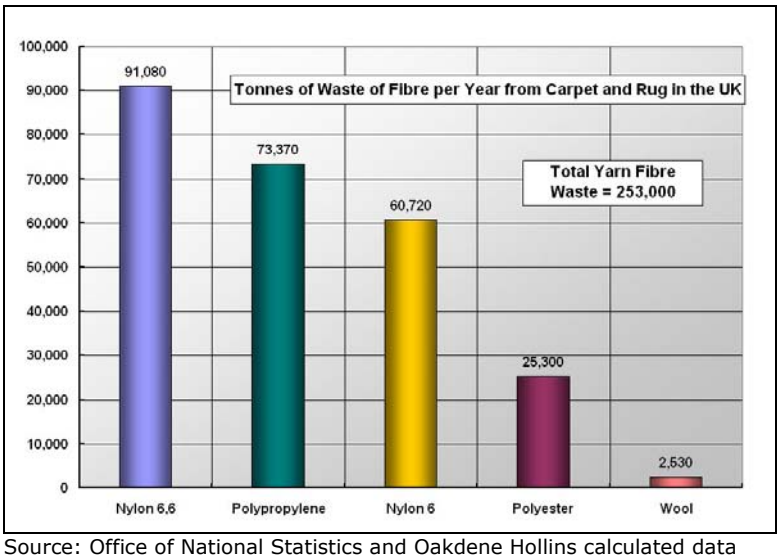
Figure 8.8: Weight % of the various fibres used in carpets and rugs



Source: Y Wang, Recycling in Textiles, Woodhead Publishing, 2006

The quantities of each type of yarn that is available for recycling is shown in Figure 8.9 below.

Figure 8.9: Tonnage of fibre type available for recycling from disposed carpet and rug each year



Source: Office of National Statistics and Oakdene Hollins calculated data

As the cost of Nylon and Nylon 6,6 is high, recycling of fibre is generally associated with these materials.

In Europe there have been a number of projects to determine the feasibility of carpet collection and recycling schemes and also to develop end products for carpet recyclates. This effort began in 1993 when the European carpet industry, represented by the industry association GUT (Gemeinschaft umweltfreundlicher Teppichboden e.V.), agreed upon the 'Vaals Declaration' to develop economically and ecologically viable disposal and recycling systems for carpets.

The TRA on Polymer Materials was an initiative set up by the European Commission to promote collaborative research and technology development between Europe's process industries and research institutes. There are four cluster groups with one dedicated to researching the recycling of polymer materials. The objective of this group was to contribute to the development of cost-effective and environmentally sound polymer recycling systems in Europe. From 1996 to 1999, a consortium of eight partners began work on the Recycling of Carpet Materials (RECAM) project, a sub-project of the TRA on Polymer Materials[97].

[97] Project Reference BE95-1337: Sustainable Closed Loop System for Recycling of Carpet Materials

The aim of the RECAM project was to develop technologies to support a sustainable closed-loop recycling and reuse system for post-industrial and post-consumer carpet waste. Eight European partners worked on a number of tasks addressing issues from collection through to the development of end markets. Specific elements of the project looked into collection, identification, sorting, cleaning, shredding, grinding, separation, mechanical / chemical recycling, closed loop recycling and life cycle analysis (LCA). The main achievements of the RECAM project were:

- a pilot project for the collection and reclamation of 20,000 tonnes of carpeting annually via Carpet Recycling Europe
- development and industrial implementation of a hand-held identification device for fibre recognition
- development of a rapid identification device (CONCORE). COCARE was developed as a coding system for easy carpet identification. Its goal is the simplification of recycling for textile floor coverings through the development of a standardised European code for textile floor coverings and the creation of the necessary technical prerequisites. A code is applied to the back of the carpet during production while at the same time the data relevant to recycling are stored in a database. The stored data is collected centrally and forwarded to the recycler.
- planning of a sorting centre and in-depth development of a handling system
- development of a simple depolymerisation process for treating polyamide carpets (PA6) without previous separation of other carpet constituents
- demonstration of the distinct ecological benefits of introducing carpeting recycling as developed in the various process variants.

Carpet Recycling Europe (CRE) was set up in 1998 as a pilot project with the fundamental aim to implement the results obtained from RECAM. CRE established the first automated sorting plant for carpet in Mainz to gather the data needed for the economic, technical and ecological evaluation of carpet recycling. The Mainz plant was able to sort up to 3.5 tonnes of carpet per hour for recycling. This pilot project demonstrated that the economic conditions at the time made recycling unfeasible as it was still possible and cheaper to send end-of-life carpet to landfill and this resulted in the plant closing in 2002.

In 2002 Carpet Recycling Netherlands (CRN) was established to assess the feasibility of introducing a carpet waste recycling scheme in the Netherlands. The project results recommended that carpet waste be collected separately for use as a secondary fuel. These conclusions were based upon the outcomes of a comparative study between energy consumption and energy

savings and a complex LCA study (see [98]), based upon the RECAM LCA study. There is no evidence to suggest that this has been implemented in the Netherlands to date.

8.5.2 Fibre identification in carpets and rugs

Carpet recyclers need to identify the pile fibres in order to find the best value for materials recovered from them. Carpet Recycling UK have engaged with the two major US manufacturers of near infra-red identification (NIR) technology to address the problem for UK recyclers. In the UK, market pile fibre blends, particularly with wool, are well established and therefore instruments had to be modified to meet UK needs.

8.5.3 Mechanical recycling of carpets

Mechanical recycling is the most commonly used recycling process. Carpet fibres are separated and shredded for use in lower or higher value products. A pelletizing machine can be used for polymer based carpet materials and these can then be used for injection moulded or extruded products. For wool-based carpets, shredded material is sold for use in a number of applications including animal bedding.

In the UK, mechanical recycling is in operation albeit on a very small scale. However, mechanical recycling of carpet in niche areas, such as the exhibition industry, is evident. Although not directly aligned with the construction, demolition and refurbishment industry, the exhibition and events sector has provided some interesting information with regards to the recycling of carpet products.

As a whole the UK exhibition sector consumes approximately 6,000 tonnes[99] of product, mainly polypropylene. This compares to the theoretically available quantity of polypropylene generated from post and pre-consumer carpet and rug waste which is approximately 73,000 tonnes.

In partnership with the Polymer Cluster[100] based at Warwick University Reeds Carpet, the UK's largest exhibition carpeting contractor, has developed a recycling system for polypropylene exhibition carpets. A pelletizer converts end-of-life exhibition carpets into polypropylene pellets which are then sold onto product manufacturers. A collection service is offered to

[98] CARE Annual Conference, May 10-12, 2005 "Update on European Carpet Recycling Activities and Experiences", Dr Edmund Vankaan.
[99] 'Innovation in "Green" Technology Wins Reeds Carpet Recycling Ltd Prestigious Award' Business Today Issue 133 p24 Northcliffe Press
[100] Polymer Cluster - provides practical support and collaborative opportunities to small and medium-sized enterprises working in the polymer industries in the West Midlands region. http://www.polymercluster.co.uk/

contractors for 2,000 m² or more of exhibition carpet which have been used within a 150 mile radius of Coventry. Deliveries are also accepted directly to the plant free of charge. The recycling plant has a capacity of 4,000 tonnes per year but is currently running at 1,000 tonnes.

It is believed that expanding this process to incorporate non-commercial carpet and PVC flooring is under consideration.

With regards to individual manufacturers' recycling efforts, there are a number of initiatives currently underway in the UK. Burmatex, have developed their "Recover" recycling process. Utilising a combined heat and cryogenic process, bitumen backed carpet tiles and offcuts are made into a new backing system for carpet tiles. This is currently applied to post-industrial waste only, but Burmatex are also investigating the feasibility of a take-back service for installation offcuts and end-of-life own brand carpet and carpet tile waste. Current thinking indicates that this source of carpet waste will be collected at the point of installation on the premise that replacement carpet is purchased from Burmatex[101]. Working with a number of partners, it is hoped that the scheme will be trialled initially in one area, but company plans are that this will become a UK-wide operation in the near future[102]. All collected materials will be recycled at the UK production facility in West Yorkshire.

A small number of carpet recycling businesses have been set up in the UK, and Greenback Recycling is one of the most successful to date, processing waste carpet material and recovering fibres. These are then sold as new grades of plastic recyclates and various other value-added products such as horticultural growing products.

In order to facilitate this process, collection containers are placed at a number of Household Recycling Centres across the UK where end-of-life carpets can be disposed of by the general public and small businesses. Once full, the containers are returned to the Greenback Recycling Facility, located near Swindon. Here the carpet is inspected for contamination and sorted by fibre type and backing using infra-red scanners. Once baled, the material is supplied as feedstock for the international plastics recycling market. Materials accepted include polypropylene, Nylon 6 and 6,6, hessian, jute and wool. Greenback Recycling has a capacity of approximately 4,000 tonnes per month and is currently operating at the 1,000 tonne per month level.

WM Fibres, a subsidiary of Wrace Technology (Manchester), is now no longer processing and the plant has been sold. Originally the plant used Italian machinery specially designed to deal with a range of carpets and able

[101] Burmatex – The Burmatex Approach to Sustainability, June 2007
[102] Personal communication with Burmatex

to remove the SBR latex. WM Fibres sent their recycled product, which was mainly fibre, for use in mattress making, sound proofing and other applications for felt-like materials. Much of their primary feedstock was pre-consumer waste or short-life product from exhibitions. Trials were carried out using landfill tax funding and the support of SITA and Mersey Waste with post-consumer waste but problems were encountered with the level of dust and dirt contamination.

In the USA there are a number of well established mechanical recycling schemes for post-consumer carpet. The Tandus Company, encompassing three floor covering brands (Monterey, C&A and Crossley), have three programmes currently in place to support their carpet recycling programme[103]. Describing their carpet recycling initative as "mining buildings instead of the earth for resources", the three supporting programmes, Infinity Initiative, Retrieve and FLOORE, each contribute to the collection and recycling of carpet waste. To date the programme has diverted approximately 60,000 tonnes of carpet from landfill in the USA and displaced the equivalent in virgin material from the manufacturing process. C&A also offer customers a unique Sustainability Warranty which guarantees that all reclaimed materials will never be sent to landfill or incinerated.

Created in 1994 the Infinity Initiative recycled post-consumer carpet into a new 100% recycled content carpet backing called ER³. This backing consists of 25% post-consumer carpet with the remaining 75% consisting of post-industrial waste from carpet manufacture and industrial waste from the automotive industry. The Infinity Initiative process consists of the following stages:

Size Reduction: Reclaimed material is transported to a central processing facility in Dalton, Georgia where it is reduced in size to small pieces ready for processing.

Pelletizing: The size-reduced carpet is then processed into fine, uniform sized pellets.

Extrusion: The pellets are then extruded into a continuous, pliable rope which is transported by conveyor belt to the calendar.

Calender: At this stage, the pliable material is rolled into a recycled composite sheet backing.

Cutting: The final backing material is rolled and cut ready for bonding to nylon face materials and surplus stock is stored in rolls.

[103] http://www.tandus.com/sustainability/recycling.aspx

The finished Product: is a 100% recycled content backing which is also 100% recyclable.

Through their 'Retrieve' programme, samples and product folders are retrieved at end-of-life and these are reused and recycled in the Infinity Initiative.

To ensure a continuous supply of vinyl-backed carpet and vinyl waste for the Infinity Initiative, Tandus established a carpet buy-back programme, 'FLOORE'. This provides a financial incentive for customers to return and recycle old nylon carpets which are uplifted when new Tandus flooring is fitted. All makes of uplifted carpets are accepted and these are then processed in the Infinity Initiative.

Although Tandus products are sold in the UK through their subsidiary, CTF-IPS Flooring Ltd, there is no UK based recycling facility in place at the moment and collected tiles are currently sent back to the USA for processing. This may be a feasible option for the UK in the future if the PVC backed carpet market grows from its current share of 25% although this would require significant start-up funding to set up and operate a supporting recycling facility.

The Antron Reclamation Programme, also operating in the USA, is another example of mechanical recycling. After starting efforts to recycle Nylon in 1985, INVISTA finally initiated the Antron Reclamation Programme carpet reclamation and recycling programme in 1991, alongside a consortium of environmentally aware carpet manufacturers, flooring contractors and end users. Recycling all types of carpet, more than 50,000 tonnes have been recycled since 2001 effectively saving approximately 280,000m^3 of landfill space. It is stated that around 700 tonnes of carpet can be processed every month at the Antron Reclamation Centre in Calhoun, Georgia, which is supplied by over 80 collection sites in the USA[104].

Some of the carpet based products that contain post-consumer recycled content, include EcoSoft carpet cushioning which contains 100% recycled content, of which 50% is post-consumer. The recycled carpet is also used as feedstock material for a variety of other products including carpet engineering resins, automotive parts, furniture, pallets, filtration pipes, stepping stones and ceramic tile backing.

The Antron Reclamation Programme accepts any type of carpet from any source. The features of the programme are as follows:

[104] http://sustain-ed.org/PAGES/Waste/dupont_detail.htm

- carpet is collected from central collection facilities, from dealers or directly at the processing site
- inspection and evaluation of delivery takes place to determine the reclamation route
- reuse is the priority: if the carpet can be refurbished it is donated to charity or sold on for a nominal fee
- if recycling is deemed more appropriate the carpet is mechanically processed into feedstock material
- the recycled material is packaged, sold and shipped to product manufacturers who incorporate the recycled content into the production of new products in varying percentages
- end-of-life carpet that cannot be reused or recycled is converted into carpet-derived fuel
- no carpet is ever sent to landfill
- a full audit trail of the carpet recycling process is made available upon request

A specification[105] is also available which provides guidance for the removal of used carpet and offcuts from installation for reuse and recycling.

Mechanical recycling of post-consumer carpet tiles is also possible, and there are a number of examples to prove this. Interface recycles PVC-backed tiles to provide feed stock for their GlasBac backing material. Upon collection, the end-of-life product is assessed as to whether it is suitable for the recycling process. If suitable, the backing material is separated and processed into a sheet material for use in the GlasBac backing system.

In the UK, Renewal Carpet Tiles supplies two types of carpet tile; one with a Nylon face fibre and the other, incorporating a wool mix face fibre. Both of these products are backed with RenewGel which contains primarily chalk and rubber and is 100% recyclable. Renewal also has a scheme in place to uplift the product at end of life. The uplifted product is returned to the manufacturing site where it is processed into a powdered material which is used in the manufacture of an underlay product, Re-Lay. This underlay can be used in commercial and domestic wool carpet installations. However, no data on volumes are available as this is a new scheme using tiles which have only been in the marketplace for around three years and are not yet ready for the recycling process[106]. (Their estimated lifespan is approximately six years.)

Previous research on recycling carpet tiles includes a WRAP-funded project demonstrating the feasibility of recycling carpet tiles for use in an acoustic underlay product[107,108]. Undertaken by the University of Bradford, the Bolton

[105] http://antron.net/pdf_files/long_form.doc
[106] Personal communication with Renewal Carpet Tiles
[107] Mohsen Miraftab, Ian Rushforth and Kirill Horoshenkov, AUTEX Research Journal, Vol. 5, No2, June 2005 © AUTEX, "Acoustic underlay manufactured from carpet tile waste, Part 1"

Institute and AngloFelt, samples were produced from granulating PVC-backed carpet tiles and binding the waste together with SBR foam. Trials indicated a good performance when compared to other commercial underlays.

Barriers	Opportunities & Benefits
Previous failures in UK/European carpet recycling.	Technically successful projects. Recycling proven in niche markets. Market development potential in several large markets. Commercially feasible US ventures.

8.5.4 Chemical Recycling of Carpets

The chemical recycling process involves separating the face fibre from the backing material and applying a depolymerisation technique to the face fibre. The raw materials can be extracted for reuse either in new carpet fibre production or in other products. Potentially, this method can enable closed loop recycling although this is currently only commercially available for Nylon 6 and 6,6 fibres.

Nylon 6 is relatively easy to depolymerise to produce the base material caprolactam. Nylon 6,6 is not as easy to depolymerise but technologies have been developed that enable depolymerisation of mixed Nylon using ammonia. This produces the two compounds caprolactam and 1,6-diaminohexane which are used to make Nylon 6 and Nylon 6,6 respectively. The overarching benefit of chemical recycling is that there is no resulting loss in product quality and the process can be repeated.

Chemical recycling of carpet is limited to Nylon 6 and 6,6 fibre types, although this is not a new technology. BASF have been recycling post-industrial Nylon 6 in the USA for more than 30 years and have recently developed technology to recycle materials with a low Nylon 6 content. This involves a six stage process:

- carpet collection
- carpet separation
- monomer recovery (caprolactam)
- polymerisation
- fibre spinning
- carpet manufacture.

Carpet recycling has not always been a commercial success in the USA. In 2000, the first commercial Nylon 6 recycling plant opened in Augusta,

[108] Mohsen Miraftab, Ian Rushforth and Kirill Horoshenkov, AUTEX Research Journal, Vol. 6, No 1, March 2006 © AUTEX, "Acoustic underlay manufactured from carpet tile waste, Part 2".

Georgia. A joint venture between DSM Chemicals and Honeywell International, the plant was capable of processing approximately 90,000 tpa of used Nylon 6 carpet waste. This equates to almost 20% of all Nylon 6 disposed of annually in the USA. A patented depolymerisation process enabled caprolactam, the key building block of Nylon 6, to be recovered from end-of-life carpets without any detrimental effect on technical properties. The recycling process eliminated the need for mechanical separation as whole carpets could be fed directly into the system.

Production at the plant ceased in August 2001 due to problems with high running costs, plant inefficiencies and a low demand for caprolactam. There were also problems with the supply of waste materials as the collection system took longer to set up than anticipated. However, in 2006 Shaw Industries acquired complete ownership of the Evergreen Recycling facility. The recycling plant re-opened in 2007 and the machinery was upgraded to allow for the processing of up to 135,000 tonnes of carpet waste each year, reclaimed through partnerships set up with a number of recycling companies across the USA[109]. Shaw Industries also runs a waste-to-energy project in Dalton, Georgia utilising a gasification unit that converts post-consumer and post-industrial carpet waste and laminate wood dust into energy. This process converts around 16,000 tpa of carpet waste and 6,000 tpa of wood flour.

There are currently no chemical recycling facilities in the UK although a carpet recycling plant was opened in Germany around the same time as the sites in America, mentioned above. Carpet was collected from across Europe and transported to Premnitz in Germany where it was then sorted according to fibre type. Nylon 6 and polypropylene was recycled chemically and Nylon 6,6 mechanically recycled and pelletised for use in low-grade components. All other fibre types were utilised in the energy-from-waste (EfW) facility at the factory site. However, the logistics of collecting and transporting end-of-life carpet were difficult and yield rates were low. Combining this with the poor economic feasibility and lack of end markets for the recyclates, the operation was closed in 2003.

Barriers	Opportunities & Benefits
Previous failures. High costs. Collection logistics. Lack of end markets for some chemical products	Long term energy/carbon costs should improve economics.

8.5.5 Energy recovery

Carpet can also be incinerated to produce energy. In 1995, after the identification of a lack of data with regards to incineration of carpet waste,

[109] http://www.shawfloors.com/Shaw-Environmental/Carpet-Recycling-Collection

the Textile and Flooring Institute GmbH (TFI) in Germany, in partnership with the Forschungszentrum Karlsruhe, investigated the co-combustion of carpet waste with household waste. Ashes and emissions from municipal waste incineration plants were tested with trials undertaken at the TAMARA research plant. The study concluded that the co-combustion of carpet waste in modern municipal waste incineration plants does not lead to any negative influences to the environment.

Another project undertaken by the TFI in 1995 investigated whether shredded or pelletised carpet waste could be used as fuel in fluidised bed reactors in order to recover energy and compared this to other fuel types such as coal. It was found that carpet with a natural fibre type such as wool has a low calorific value (approximately 19 MJ/kg) compared with Nylon carpets which were found to have an average calorific content of 26 MJ/kg. Polypropylene carpets had the highest calorific content at 42 MJ/kg.

Carpet backings can hinder the incineration process, particularly chalk filled SBR. There have been some developments in overcoming this. In the UK, Brockway Carpets have developed an environmentally friendly carpet backing, 'Envirobac', which uses polyethylene as an adhesive, eliminating the need for SBR. Developed as part of a DTI-funded project with a German textile manufacturer in 1996, approximately 12 million m² of Envirobac has been used to date[110]. One benefit is that this can be incinerated at end of life without producing toxic emissions, and it has a calorific content similar to that of coal. Brockway Carpets is one of only two manufacturers in the UK using this system, the other being Victoria Carpets.

Barriers	Opportunities & Benefits
Regulation concerning waste incineration.	High calorific value

8.6 Carbon impact of end-of-life options

Having reviewed reuse, recycling and energy-from-waste options from a technical and market perspective, this section reviews whether there are environmental preferences based on a review of life cycle assessment literature. This is not comprehensive, and only carbon impact has been considered.

A greenhouse gas benefit has been attributed to the displacement of materials through recycling. There is limited literature on the carbon impact of various disposal options for textiles. Energy from waste (incineration) is a common end-of-life option that is modelled in the literature. The electricity generation is related to the calorific value of the waste stream and process

[110] Personal communication with Brockway Carpets

emissions of carbon dioxide are based on the fossil carbon content of the waste stream. For every kWh of electricity generated through waste treatment, emissions for generating each kWh of electricity from gas was used to quantify the greenhouse gas savings. Table 8.2 summarises the current literature on the carbon impact of various disposal options. It is very difficult to compare these values as the boundary conditions and functional units for each life cycle assessment differ. Data from Ref 4 are presented in person equivalent (PE) calculated using EDIP assessment methodology. These data are converted to carbon equivalents using the normalisation factors. Data reference from 6 includes various end of life scenarios for a particular textile and are shown under the respective column in Table 8.2 depending on the major component of the end of life option (i.e. Ref 6b is a composition of various scenarios but the overall value is assigned to "Reuse" due to its large contribution).

Graphical representation of Table 8.2 is shown in Figure 8.10 for ease of visualisation to compare the carbon impacts. In Ref 1 collected textiles are assumed to consist of both natural and synthetic fibres, and both data for the production of cotton and polyester have been used to calculate the offset, assuming a 50/50 split. The carbon impact data for the cotton and the synthetic fibres production was sourced from an LCA study in the literature and from Ecoinvent, version 1.1 as polyester ("*Polyethylene terephthalate, granulate, amorphous, at plant/RER S*"), respectively. It is thought that this value is higher than currently accepted levels, as the latest version of the Ecoinvent database shows 2,360 and 2,750 kg CO_2 equivalent for 1 tonne of production, for the two fibres. Assuming 50/50 split, 2,555 kg CO_2 equivalent is the maximum available for recycling benefit. This figure is in good agreement with the other data on recycling found in the literature. We therefore believe Ref 1 to be anomalous.

The "Reuse" option modelled in Ref 6 has the highest carbon benefit when the cotton T-shirts (Ref 6b) are mainly reused (60%) to replace the original product. When the garments are trousers (Ref 6e: 65% polyester, 35% cotton), however, the reuse benefit is substantially reduced. Recycling cotton T-shirts to low value added products like wipers (Ref 6c) also substantially reduces the potential carbon benefits available when original product is substituted.

Data given in Ref 7 is based on the chemical recycling technology ECOCIRCLE™ developed by Teijin Fibers of Japan. It is claimed that the energy consumption, as well as carbon dioxide emissions, can be reduced by 80% when compared to production from petroleum. The claimed energy reduction and carbon dioxide emission reduction of 80% are based on the carbon impact of production and incineration combined. The recycling benefit shown in Figure 8.10 for Ref 7 was calculated excluding the carbon burden from incineration of which shown separately.

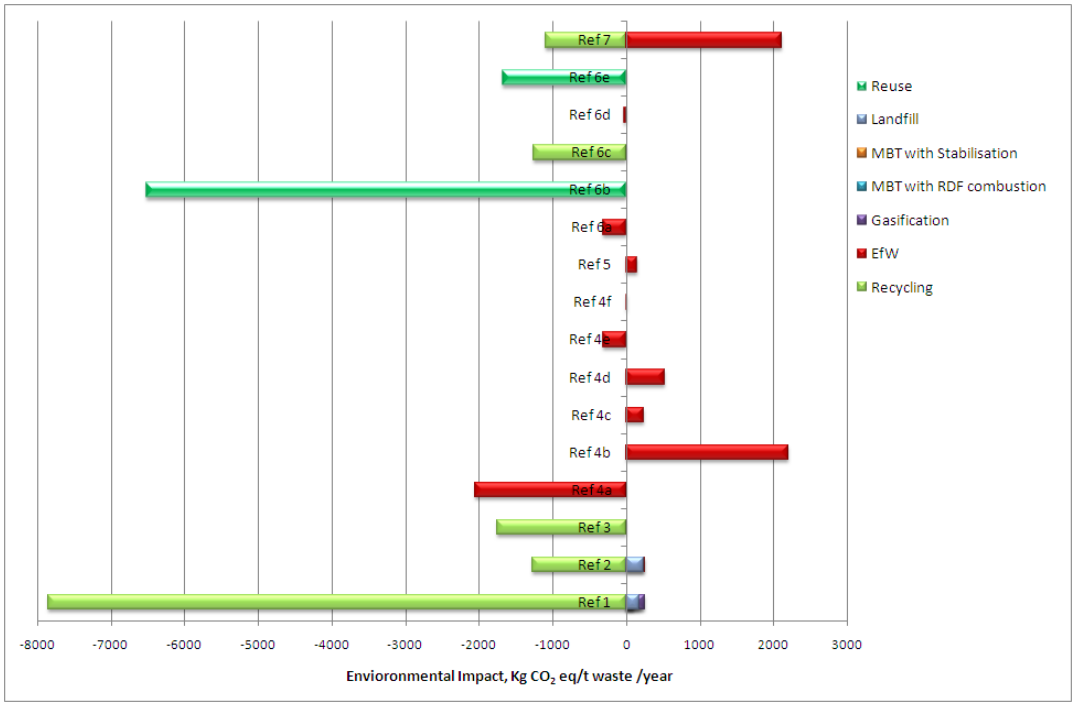
Generally the results are in good agreement with the waste or resource hierarchy, favouring reuse of the product above recycling the material, and with energy from waste and landfill as the least preferred options.

Table 8.2: Carbon impact of various end of life options available in the literature for a tonne of waste textile processed

	Kg CO_{2e} / tonne of textile waste processed							
	Recycling	**EfW**	**Gasification**	**MBT with RDF combustion**	**MBT with Stabilisation**	**Landfill**	**Reuse**	
Ref 1	-7853	218.56	248.9	97	95.1	171.32	*na*	Impact of Energy from Waste and Recycling Policy on UK Greenhouse Gas Emissions, Defra, Jan 2006
Ref 2	-1284	245	*na*	*na*	*na*	233	*na*	Waste Strategy for England 2007-Defra
Ref 3	-1750	*na*	*na*	*na*	*na*	*na*	*na*	Carbon Balances and Energy Impact of Management of UK Wastes-Annex B Dec 2006
Ref 4	*na*	-2051	*na*	*na*	*na*	*na*	*na*	EDIPTEX – Environmental Assessment of textiles-Working Report 24-2007 …T-shirt of 100 % cotton (250 g)
Ref 4b	*na*	2201	*na*	*na*	*na*	*na*	*na*	…jogging suit of nylon microfibres with cotton lining, 706g
Ref 4c	*na*	241	*na*	*na*	*na*	*na*	*na*	…work jacket of 65 per cent polyester and 35 per cent cotton, 770g
Ref 4d	*na*	517	*na*	*na*	*na*	*na*	*na*	…blouse of viscose, nylon and elastane,200 g and 125 g per m^2
Ref 4e	*na*	-316	*na*	*na*	*na*	*na*	*na*	…tablecloth of cotton, 100%, 384g
Ref 4f	*na*	17	*na*	*na*	*na*	*na*	*na*	…composite floor covering, nylon, polypropylene and latex foam, 2633g/m^2.
Ref 5	*na*	145	*na*	*na*	*na*	*na*	*na*	Ecoinvent database version 2.0 (textiles disposal, soiled, 25% water, to municipal incineration)
Ref 6a	*na*	-310.71	*na*	*na*	*na*	*na*	*na*	Laura Farrant, Environmental benefits from reusing clothes, MSc Thesis, July 2008, Technical University of Denmark …T-shirt of 100 % cotton (250 g), discarded for EfW
Ref 6b	*na*	*na*	*na*	*na*	*na*	*na*	-6525	…T-shirt of 100 % cotton (250 g), 60% reused, 30% recycled 10% landfilled

	Kg CO_{2e} / tonne of textile waste processed							
	Recycling	**EfW**	**Gasification**	**MBT with RDF combustion**	**MBT with Stabilisation**	**Landfill**	**Reuse**	
Ref 6c	-1258	*na*	*na*	*na*	*na*	*na*	*na*	…T-shirt of 100 % cotton (250 g), Recycled 90% wipers, 10% EfW
Ref 6d	*na*	-32	*na*	*na*	*na*	*na*	na	…Trouser (65% polyester, 35% cotton), discarded for EfW
Ref 6e	*na*	*na*	*na*	*na*	*na*	*na*	-1682	…Trouser (65% polyester, 35% cotton), 60% reused, 30% recycled 10% landfilled.
Ref 7	-1102	2103	*na*	*na*	*na*	*na*	*na*	ECO CIRCLE™ Teijin Fibres Close Loop Recycling System, http://www.teijinfiber.com/english/index.html

Figure 8.10: Carbon impact of various end of life options available in the literature for a tonne of waste textile processed



8.7 Conclusions and recommendations

Using the conclusion on the carbon impact of textiles, we may prioritise the reuse and recycling of textiles as follows, summarising the barriers and opportunities identified in Sections 7 and 8 as:

Strategy	Barriers	Opportunities
Reuse - UK	General negative perception of reused clothing	Eco- and thrift image among certain customer market segments
	Low pricing of budget retailers	Internet-based sale / donation / swapping
		Greater doorstep collection possible via Local Authorities
		Favourable economics down to very low prices
Reuse - Overseas	Perceptions of damage to indigenous textiles industries	Large markets with current strong demand
	Recycling rates and eventual fates of textiles not well known	Favourable economics for sorting and sale
Recycling	Many markets are low or negative growth with low prices	Possible new markets in concrete reinforcement (carpet fibres in particular), agriculture/horticulture and insulation (thermal and acoustic)

Strategy	Barriers	Opportunities
	Attractive fibres (e.g. wool) are declining in availability	Poor public understanding of attractiveness of collecting recycling grades
	Many potentially recyclable fibres lack markets e.g. carpet	Added value to recycled fibres through the use of additives
	Reluctance to change from existing materials to recyclates (e.g. fibres for concrete), particularly where these materials may already be low cost	Chemical recycling of corporate clothing and other synthetic-fibre rich consistent streams
	Post-consumer textile waste is forbidden (draft BS for geotextiles)	Copying of US carpet recycling initiatives e.g. nylon 6 recycling
	Separation of fibre from backing of carpets difficult to achieve	
	Several well known economic failures of UK/European textile recycling operations inhibiting action	
	Logos and branding of corporate clothing	

Our recommendations are therefore as follows:

- promotion of a positive image of reused clothing by charities, designers and those concerned with sustainable clothing.
- design and purchase of long lasting styles (e.g. by schools).
- audit trails and published recycling/reuse rates by textile recyclers and charities in order to give public confidence through transparency, and to identify serious long term organisations with whom Local Authorities would want to collaborate.
- partnership with indigenous industries (e.g. remaking/modification) to impact textile industries in developing countries more positively.
- innovation funding to create new markets and overcome specific technical issues.
- development of geotextile specifications that may use recycled textiles.
- review past failures of UK/European recycling to determine key factors for success in future initiatives.
- market development funding, including demonstration, standards and/or capital funding for selected new markets for recycled textiles, for example thermal insulation and concrete reinforcement.

It is clear that there is a need in the UK to continue investment in new technologies for increasing the value of recycled textiles. This not only includes advances in mechanical and chemical processing but also includes managing the recycling of fibre and textiles containing larger quantities of biodegradable and compostable materials entering the waste stream.

Manufacturers of textiles and textile products using biodegradable and compostable fibre should be encouraged to gain certification and apply the appropriate mark to avoid confusion with the general public about what is meant by biodegradability and compostability. This would assist downstream or secondary recycling.

Further support and encouragement should be provided to Carpet Recycling UK in order to strengthen the UK carpet manufacturing and recycling industries. The structure and operations of the organisation CARE (Carpet America Recovery Effort) offer a good business model for the promotion of carpet stewardship.

Quality Standards and Protocols

There are several different industries involved in recycling textiles, these include:

- collection
- garment reuse (charity shops and international exports)
- sorting
- textile reuse (rags and cloths)
- fibre reuse (nonwoven textiles).

The development of standards within textile recycling should therefore examine all aspects of the industry.

8.8 Collection of post-consumer textiles

The collection industry could not foresee a satisfactory mechanism for controlling the quality of material entering the waste stream. The collection of the material, through door-to-door collection, textile banks or direct donation to charities relies on the goodwill of the public and enforcing quality control at this stage would prove difficult, and potentially reduce textile recovery rates.

A code of practice or accreditation of textile collectors was suggested. It is difficult to envisage how such scheme would increase diversion of textiles from landfill because door-to-door collections are self-funded therefore it is in the interest of collectors to minimise landfilled material. The argument for such schemes has been to increase revenues to charitable organisations. Such a scheme may be beneficial in ensuring that the most appropriate or environmentally sound route is developed for these textiles.

8.8.1 Garment recycling

Industry members did not believe it practical to develop standards for the reuse of garments. Fashion, state of repair, and even cleanliness did not appear to be barriers to the sale of items of clothing.

8.8.2 Sorting

Exporters of sorted and unsorted textiles are encountering differences in the definition of waste for moving textiles across national borders. This is leading to cases where material can be exported perfectly legally from one

country but is considered waste (and therefore illegal) in the destination country. Harmonisation of the interpretation of the definitions of waste across Europe could resolve this problem. It is clear though, that some inspection and sorting of the material within the UK would be necessary in order for any compliance approval to be given. By definition, activities required to sort and grade textiles in the UK prior to exporting would make foreign operations set up specifically for the purpose of sorting unsorted textiles redundant. There is an argument that this may increase the cost of exporting textiles and may result in a reduction of diversion from landfill as foreign buyers move to cheaper sources of textiles from alternative countries. However, the alternative argument is that some sorting in the UK will ensure that a minimum quality standard of the exported textile is being met ensuring that significant quantities of waste or unusable textiles are not being transported internationally. To avoid this, the production of a UK standard that defines the point at which textile waste becomes a useable resource must be ratified through international consensus.

In a related theme, WRAP and the Environment Agency have recently initiated a programme to develop protocols that enable material waste reprocessors to reclassify their waste material as a useable material. Such a scheme could be the first step in developing international standard.

The TRA has published a specification for textiles derived from charity shops. It describes the quality of material unsuitable for sale in charity shops which is sold on to textile recyclers. The standard is non-specific, stating that the textiles should be from UK sources, homogenously mixed, clean and dry. The textile material should be free of other items, such as books, games, carpets and duvets, and packaged separately from shoes and bags. It also mentions the need for the textiles to be bundled in easily manageable weights (8-10kg).

8.8.3 Textile reuse

The TRA have also published a standard for wiping cloths. It defines a series of grades of wiping cloths, which both aids in the harmonisation of the industry and ensures that a purchaser is confident in the product. Nine different grades of wiper are briefly specified including fibre composition and materials that should be omitted. The standard also specifies that the wipers should be dry, clean, of a certain minimum size and not contain reused wipers.

Clearly, the TRA have published these standards in response to members' requests and further work in this area may yield the development of a nationally recognised standard.

Vendors of sorted and unsorted textiles suggested that there was little need for standards for the sale of waste textiles because their customers set specifications for their material. They also felt that the diversity of material and the end uses suggested that a single standard would be either too broad to be effective or too narrow to enable wide application. This, though, is in conflict with views expressed by buyers of sorted textile material where there is some appetite for a series of recognised standards that ensure that the quality of material delivered to them is of a specified standard.

8.8.4 Fibre recycling

Textile shredders and felt manufacturers were interested in the development of standards for the quality of material that they received. Even when specified in the purchase, it was difficult to ensure homogenous fibre composition including fibre type, length and tow of the textile. The quality of this starting material affects the overall quality of the resultant shred and therefore accurate information is an important factor in determining the output quality of the nonwoven textile. In addition, in certain circumstances, there are safety implications for products requiring high levels of fire resistance which use high levels of wool. It is difficult to guarantee, without robust controls, the wool composition of a batch of rags destined for shredding.

Purchasers of reclaimed fibres from shredders also expressed an interest in specification of the material they received. In addition to the information requested by textile shredders on fibre composition, they were interested in developing standards which prohibited the inclusion of foreign material such as buttons and zips and ensured that the delivered fibre length is greater than a specified minimum (under which felting is difficult without specialist machinery). However, there were concerns that although a standard would improve quality of material, the current scarcity of material in the marketplace meant any mechanism which may initially remove textiles from the waste stream, would affect the quantity of material available for use and should therefore be avoided.

8.9 Other material standards

It is important to examine other standards which are available for alternative waste streams. The most prominent of these are those developed by WRAP in collaboration with the BSI. They have developed several Publically Available Specifications (PAS) for waste material. Specifications for:

- composting (PAS 100)
- glass collection (PAS 101)
- processed glass (PAS 102)

- plastic packaging (PAS 103)
- waste wood (PAS 104)
- paper (PAS 105)
- tyre shred and granulate (PAS 107)
- tyre bales for construction (PAS 108)
- recycled gypsum (PAS 109)

have been developed for waste material. WRAP has also developed a standard for the production of aggregates from inert waste, which appears to be aimed primarily at ensuring the aggregates are of sufficient quality to not be considered waste. This standard appears to be similar to the recent call for proposals for standards for recycled materials from WRAP and the Environment Agency. These standards have several important features, which may be appropriate in the development of a waste textile standard:

Grading of material: Standards can apply to different grades of material entering and leaving recycling facilities. It is acknowledged that there are many different grades of material both at the point of collection, which can be dependent on source, or the onward sale of material, which is dependent on its use. Material composition of batches of recyclate are specifically defined to encourage conformity across industry. This can also include morphology of the material, its colour and its bulk form.

Recording of graded material: There are several examples in the standards of logging and grading of material: importantly, a framework is given to ensure that the method of recording this information is harmonised. Also, specification of a minimum set of requirements before a batch of material can be labelled of a specific quality brings transparency to the marketplace.

Contamination: Limits on the level and types of contamination of recyclate material are described; this ensures that material which is unfit for recycling is removed during sorting and that the recyclate is in a suitable condition for further processing.

Storage and delivery: Guidelines are given on the storage and transportation of recyclate. This is to ensure that the material is exposed to a minimum number of contaminants prior to recycling and can have an effect on the quality of the material. This is clearly important where reuse is an option in recycling textiles. Information on the type and size of container is also given to aid handling of the recyclate. Guidelines also describe safety protocols that should be followed (beyond the statutory minimum) to ensure that the material is stored safely.

Testing procedures for grading: Information is provided on the standard test which must be performed to determine the grade and quality of the goods; this can range from visual inspection through to laboratory screening.

Technologies used: Information is given on the most appropriate equipment for reprocessing the recyclate. This ensures that the product at the end of the process is of a well defined quality.

8.10 Potential issues for developing standards for textiles

Through conversations with stakeholders, there are several barriers which need further investigation and may need to be overcome before a robust standard can be developed:

- the diversity in both types and blends of textiles makes identification and grading difficult, and labour intensive.
- due to collection through public charitable donations, it will be difficult to impose standards on collection of material.
- the diverse nature of the industry means that a single standard may be too broad or restrictive to be effective whereas multiple standards may not achieve universal recognition or may confuse, rather than clarify, the market.
- the broad scope of the industry means that a standard may be welcomed by one sector but resisted by another making overall adoption and drafting difficult.

8.11 Recommendations

- Several examples of the potential benefits of standards have been identified within textile fibre recycling. Standards within this area should be explored both in traditional and novel fibre markets. PASs form a possible approach to some of these.
- Quality protocols are of less use in creating markets for waste textiles, although of more possible assistance in carpet recycling

9 Summary of Recommendations

9.1 Legislation and policy (Section3)

The legislation in place affecting the secondary markets and collection of textiles has changed very little since the previous report. However, the issues raised in 2006 do not seem to have been resolved adequately, with the main problems occurring around the clarity and enforcement of regulations involved. Specific recommendations are as follows:

- Greater clarity is needed on waste definitions, particularly in regard to textile banks. As most of the content is reusable 'as is', this is perceived to be non-waste, and as such should be exempt from waste regulations. However, clothing which is exported unsorted should become more traceable, with recycling and reuse rates published by individual recyclers or industry bodies, in order to ensure responsible recovery methods are being carried out.

- The TFS Regulations require stronger enforcement. Where textiles are deemed as waste, regulations need to be adhered to. This will discourage inappropriate export of unsorted garments, and will both stimulate UK sorting, and may reduce the occurrence of unregulated collections.

- Increased communication between charities and public authorities in regards to identification of 'bogus' collections, and proper enforcement actions once these organisations have been recognised.

- Development of a universal standard - or commonly accepted and communicated CSR standards *across the whole industry* - with regard to door-to-door collections, to regulate frequency and, if marketed well, to enable the public to better recognise 'bogus' collectors.

- Removal of the licensing of door-to-door charitable collectors from Local Authority control.

- Focus on Trading Standards as the most appropriate enforcement authority for 'bogus' collectors.

9.2 Quality of textiles (Section 5)

- Attempts by charities and waste authorities to increase the rate of diversion of clothing and shoes from residual household waste is worthwhile and should be encouraged, particularly that lower value textiles are still worth recycling.

- Targeting of lower socio-demographic households will yield higher percentages of textiles. Partnerships with textile collectors should therefore ensure that higher socio-demographic households are not selected at the expense of others.

9.3 Collection, sorting and reuse (Section 6)

- Perceptions of the "dumping" of the West's surplus clothing on lower income families in the UK and overseas do not reflect accurately the long tradition of trade in used clothing.

- Previous research on consumer behaviour has identified opportunities to increase recycling by increasing the convenience of textiles collection; by communicating that cheap or damaged clothing has value to a charity or recycler and should not be disposed of as residual waste; and by the promotion of reuse between individuals. Charities and recyclers should encourage customers to donate cheap and damaged clothing, but avoiding increased collection of contaminated or damp clothing.

- Direct reuse within family/friendship networks is significant, but may be declining. Exchange or sale between individuals facilitated by the internet is growing strongly, albeit from a small base. Combined with evidence of innovation and hybrid approaches, continued growth is expected. Encouragement of classic styles and slowly changing fashion (e.g. within school clothing) will assist this. The latter issue could be addressed by DFCS in discussion with retailers over retention of similar styles over several years. This will also make thrift shop operations within schools more effective.

- Use of textile banks is growing as a collection method for used textiles. There are no significant barriers to the expansion of these schemes so long as the economics of textile recycling remain attractive. Numbers of charity shops have remained at a fairly consistent level in recent years, and no significant expansion is expected in the near future.

- There is little or no UK experience of in-store collection. International experience is of both continuous and campaign collections. Continuous

collections allied with synthetic fibre recycling have experienced some problems with consumer awareness, identification/labelling and the consequent costs. Familiarisation with other in-store collections (e.g. batteries) may change retailer perceptions.

- The availability of kerbside collection of used textiles has almost doubled since 2002 to over 30%, but is still only half of that for glass, plastics and metals. Previous consumer behaviour studies show that convenience is a major factor in increasing recycling/reuse rates for clothing. A greater proportion of LAs should offer kerbside collection of textiles so that recycling availability matches that of other recyclates

- The growth of co-mingled household collections (whereby recyclates are collected together in a single box, and sorted at a later point) is a threat to greater recycling and reuse of textiles, as textiles are unattractive to MRF operators and the collection methods result in the poor condition of the textiles. Where co-mingled collection takes place, LAs should introduce alternative textile recycling offerings such as partnerships with commercial textile recycling companies to collect textiles separately and in good condition

- Lower levels of UK sorting and the direct shipping abroad of unsorted clothing is increasing, encouraged by robust overseas reuse and recycling markets and declining UK recycling markets. A level of UK sorting is desirable in order to service UK markets and also to reduce risk of exposure to more volatile overseas trading markets. Greater transparency on fates of clothing is required from individual companies and from trade organisations. Interventions such as innovation funding, demonstration projects and capital equipment grants should be used to create new markets for recycled fibre in the UK.

- Collection and reuse/recycling of corporate clothing at end of life is lower than with conventional clothing due to the large volume of identical clothing, security and branding concerns and tax treatment. There are also opportunities due to its consistency, the increasing management by companies at end of life and increasing awareness of its environmental impact. Use of public procurement initiatives to increase the overall sustainability of corporate clothing used in the public sector, including improved end-of-life management. This might include a demonstration of closed loop recycling or reuse. Greater consistency in the application of tax rules to corporate clothing, with more detailed guidance on what constitutes acceptable corporate identification that also maximises the potential for reuse. Increased collection of used corporate clothing by companies or their agents is recommended rather than encouraging employees to dispose of clothing themselves, however, wearers should be made aware of the inherent capacity for reuse of the uniforms they wear.

- Textile rental already possesses the collection infrastructure for efficient recycling. Particular problems remain with some products such as mats and specialist uniforms such as for clean rooms. Market development via innovation or demonstration funding for specific problem products will help increase recycling rates in this sector

- A carpet collection infrastructure is being created to accept carpets and carpet tiles from HWRCs, albeit from a small base, facilitated by Carpet Recycling UK. There is a small existing collection, sorting and reuse/recycling industry, often based on social enterprises and often supported by a large carpet tile manufacturer. There are also larger scale remanufacturing opportunities in carpet tiles, currently shipped to the USA. Market development via innovation, demonstration or capital equipment funding will assist in creating more robust markets for the carpet fibre and backing that will be produced from collection and sorting and for investment in remanufacturing technology.

- It is clear that there is a need in the UK to continue investment in new technologies for increasing the value of recycled textiles. This not only includes advances in mechanical and chemical processing but also includes managing the recycling of fibre and textiles containing larger quantities of biodegradable and compostable materials entering the waste stream.

- Manufacturers of textiles and textile products using biodegradable and compostable fibre should be encouraged to gain certification and apply the appropriate mark to avoid confusion with the general public about what is meant by biodegradability and compostability. This would assist downstream or secondary recycling.

- Further support and encouragement should be provided to Carpet Recycling UK in order to strengthen the UK carpet manufacturing and recycling industries. The structure and operations of the organisation CARE (Carpet America Recovery Effort) offer a good business model for the promotion of carpet stewardship.

9.4 Barriers and opportunities for recycling (Section 8)

- Promote positive image of reused clothing by charities, designers and those concerned with sustainable clothing.

- Design and purchase of long lasting styles (e.g. by schools).

- Audit trails and published recycling/reuse rates by textile recyclers and charities in order to give public confidence through transparency, and to differentiate serious long term organisations with whom Local Authorities would want to collaborate.

- Partnership with indigenous industries (e.g. remaking/modification) to more positively impact textile industries in developing countries.

- Innovation funding to create new markets and overcome specific technical issues.

- Development of geotextile specifications that may use recycled textiles.

- Review past failures of UK/European recycling to determine key factors for success in future initiatives.

- Market development funding, including demonstration, standards and/or capital funding for selected new markets for recycled textiles, for example thermal insulation and concrete reinforcement.

9.5 Quality standards and protocols (Section 9)

- Several examples of the potential benefits of standards have been identified within textile fibre recycling. Standards within this area should be explored both in traditional and novel fibre markets. PASs form a possible approach to some of these.

- Quality protocols are of less use in creating markets for waste textiles, although of more possible assistance in carpet recycling.

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