

Remanufacturing in the UK

A snapshot of the UK remanufacturing industry

2009



FOREWORD

Reconciling future global resource needs with inevitable, but often hidden, environmental constraints is a huge challenge. Green Alliance's work with businesses over the last decade has confirmed that the primary need is for sound data, enabling us to make better decisions about what we use and how, and helping us to secure more effective resource use. In discussions about 'resource efficiency', the benefits of re-using products and equipment, as against reprocessing their materials through recycling, have often been obscured or entirely neglected.

That is why I am delighted that the Centre for Remanufacturing & Reuse, with the support of WRAP and Defra, received a mandate to conduct this research into the business impact of remanufacturing and reuse.

The current report is a timely update to the pioneering study 'Remanufacturing in the UK' published in 2004 by RRF. Emphasis on measures at the top of the waste hierarchy, especially waste prevention, should receive much greater attention through the revision of the EU's Waste Framework Directive and subsequent UK implementation.

This report firmly sets out the stall in this important area, where the potential for boosting our industries at a time of global downturn is still under-appreciated. The 2009 revision updates and refines the original by greater consideration of different ways of achieving reuse, for instance by differentiating repair and remanufacture..

The findings of the report, whilst centred on economic and environmental benefits, are intriguing in the way that the recent financial turmoil has affected different sectors. Some companies that have been flexible and adaptable, taking advantage of remanufacturing approaches, have been unaffected by recession. This points the way towards robust models of business which operate on sophisticated and interlinked mixes of new and remanufactured products and associated services. In the process, they deliver business innovation, environmental benefits, resource efficiencies and rewarding, high skill employment.

The skills agenda has never been more important, and developing the skills highlighted in this survey will help to set us on the right path.

Julie Hill
Associate, Green Alliance

August, 2010

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REMANUFACTURING IN THE UK



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1 Introduction

The 2004 survey *Remanufacturing in the UK: a significant contributor to sustainable development?*¹ marked the first UK assessment of the activity known as remanufacturing. The practice of remanufacturing, described and defined more fully in Section 2, was at the time poorly recognised and formed no part of waste and resource strategy, and certainly did not attract the support which was being aggressively placed into recycling initiatives.

Any perceptions of the domain of ‘remanufacturing’ were largely labelled with uncomplimentary phrases such as ‘second-hand’ and ‘refurbished’ and associated with charitable and low skill ventures in furniture, fridges or washing machines.

As described in Section 3, and echoing a similar study conducted in the USA, what really existed was an opportunistic, business-driven class of engineering activity. It was largely hidden but addressed – in the main – the life extension and upgrade of goods transacted between businesses. It was not motivated by environmental concerns, but the net effect of the closed-loop business systems required for retrieval of products was, without exception, beneficial in both materials and energy saving.

These attributes, although financially welcomed, were not considered to be a source of commercial differentiation or advantage, nor exploited as symbols of ‘greener’ business practices.

In many sectors there was dominance of a few large companies, but with a long tail of smaller companies often clustered around customers or other centres of activity. The definition taken for remanufacturing implied a high degree of quality control and associated warranty, which favoured the larger operators. In general therefore, we found a range of qualities of remanufacturing that embraced different levels of expectation by the customer concerned.



This scoping study and various pieces of work that followed – some for private customers, others for public sector – proved to be a sufficient evidence base to attract Defra support under its Business Resource Efficiency and Waste (BREW) programme. From 2006 to 2010, Oakdene Hollins has been contracted to promote remanufacturing and reuse by businesses in the UK.

A succession of one year business plans has begun to address the barriers that were identified such as definitions, remanufacturing standards, remediation technologies, purchaser awareness, carbon footprints, supply chain issues, product design, business model development and business leader skills.

The website www.remanufacturing.org.uk provides an enduring record of activities, resources for practitioners and purchasers, and tools for opportunity evaluation.

Activity was badged under a distinct unit within Oakdene Hollins branded as the Centre for Remanufacturing & Reuse (CRR). The title recognised what had been apparent even from the early days: that remanufacturing itself was at the highly engineering-oriented end of a spectrum of reuse.

In certain circumstances remanufacturing offered superlative financial, environmental and feature benefits to customers, but other options might be more appropriate for different categories of goods.

It was important that the scope of the CRR recognised the complexity of product use and could offer a range of so-called end-of-life alternatives including remanufacturing, refurbishing, repair, re-purposing, direct reuse (or remarketing), coupled with the conventional options of recycling, energy from waste and landfill. Over that period, partly due to the efforts of CRR and others such as Green Alliance, the acceptance of the role of reuse as part of a sustainable production and consumption strategy has risen significantly.

Reuse was recognised in Defra’s 2007/08 Waste Strategy, and receives substantial treatment within the EU’s revised Waste Framework Directive, which recognises the resource impacts possible from reuse and the need to differentiate it from waste treatment.

The WRAP (Waste & Resources Action Programme) AGM of November 2009 may mark a pivotal moment in attitudes to reuse.

Under a revised Defra resource efficiency support programme, WRAP will take responsibility for coordinating the delivery of most of the component services previously under BREW. This will entail a migration away from its heartland of waste treatment and materials recycling into more complicated activities.

A recent SEI report² commissioned by WRAP has been instrumental in summarising the relative impacts of its traditional activities based on material recovery to the improved efficiencies available from product reuse-based systems. In a relatively short time, therefore, we anticipate a major shift towards addressing the challenges of reuse, including remanufacturing.

Survey, Scope and Objectives

In the meantime, progress and support is still predicated on a sound evidence base. This survey is CRR’s attempt to take a snapshot of the sectoral trends and impacts six years after the first effort. Its purpose differs from the first report as outlined below.

- **Objective** - To identify significant changes over time in the underlying activity within a range of product sectors. Impacts are financial and material. [In contrast, the original survey concentrated on constructing a baseline for manufacturing activity]
- **Scope** - To differentiate between classes of activity (and nomenclature) in manufacturing sectors. This will embrace: remanufacturing; refurbishment/repair, and; reuse. [In contrast, the original survey considered only manufacture or near manufacture]
- **Use** - To help WRAP, Defra and other Government departments and agencies to characterise and identify high impact opportunities for intervention in promoting reuse and the associated diversification in business models that often accompanies that. It will not discuss what possible interventions to promote might be. [In contrast, the original survey concentrated on identifying both barriers to further uptake and possible actions]

Contextual Factors

With respect to the quality of survey data, a number of caveats apply. At the time of writing, the UK is still – technically – in recession, having suffered 18 months of economic downturn. The effect of this on the manufacturing sector has been severe: For example, sales of some machine tools fell by 50 - 60% over the last year.

All other things being equal, one would therefore expect that measurements of related manufacturing activity would see similar effects. However, this is not necessarily so. All previous work in remanufacturing has identified that there tends to be a greater diversity of selling options within reuse, embracing lease, deposit-return, programmed remanufacture, part remanufacture and pay per use as well as straight sales. This means that:

- Ownership does not necessarily reside with the user. Consequently costs can be variabilised with onus on the supplier to extend product life.
- True closed-loop remanufacturing means that a sale becomes the service of an existing installed asset base, not a difficult capital purchase for a cash-strapped supplier. New sales are discretionary, servicing is imperative.

As a result, many remanufacturers have been less affected by the recession than pure manufacturers. Some have thrived. Anecdotally, one pump remanufacturer said, “There hasn’t been a recession; our business has increased”. Others with manufacturing and remanufacturing flexibility have shown great resilience by flexing their business to the service side.

A telling example in the machine tools sector is of a (re) manufacturer which included a financing package in its sales repertoire. Its business declined only 10% over the last year compared to the industry norms.

We would not claim that remanufacturing is immune to recession, only that the combination of closed product loops and product-service-oriented business models offers a greater resilience to economic fluctuations. Nevertheless, the limited nature of the survey means that attempts to produce absolute performance

data have been severely hampered by the complexities associated with the macro-economic background, sector fortune and business model.

The survey is therefore best seen as an indicator of the balance of the reuse options per sector and as a highlighter of significantly impacted sectors, good or bad.

2 Defining Remanufacturing

In 2001, as well as the lack of awareness of remanufacturing, there was a wide variation amongst practitioners of the nomenclature of their operations. These operations, when examined in detail, conformed to the working definition of remanufacturing that we adopted. The topic appeared early in the list of issues that stakeholders wanted Defra to address, and therefore CRR has invested substantial effort in it.

The first action comprised a review of practices and definitions across manufacturing, service and repair. This resulted in a report, *A Review of Reuse Definitions*³, highlighting similarities and differences. Subsequently, CRR was approached by The British Standards Institution (BSI) to investigate the need for and scope of a British Standard that covered end-of-life options including remanufacturing.

We have been delighted to be part of that effort which has now culminated in the publication of a standards document, *BS8887: Part 2*⁴, where terms relevant to this field are defined and described.

BS8887: Part 2 defines remanufacturing as:

“returning a used product to at least its original performance with a warranty that is equivalent to or better than that of the newly manufactured product”

This comes with a number of explanatory notes:

- From a customer viewpoint, the remanufactured product can be considered to be the same as the new product.
- Remanufacturing may not use repaired or reconditioned parts.

- With respect to remanufacture:
 - manufacturing effort involves dismantling the product, the restoration and replacement of components and testing of the individual parts and whole product to ensure that it is within its original design specifications
 - performance after remanufacture is expected to be at least to the original performance specification
 - any subsequent warranty is generally at least equal to that of new product.

This is to all intents and purposes the definition used in the 2004 survey and considers the most quality-oriented end of the spectrum. *BS8887: Part 2* also addresses other reuse options including reconditioning, repurposing and repair:

- **Reconditioning** - Returning a used product to a satisfactory working condition by rebuilding or repairing major components that are close to failure, even where there are no reported or apparent faults in those components. There is the important rider that any subsequent warranty is generally less than for a new or a remanufactured product, but the warranty is likely to cover the whole product (unlike repair). Accordingly, the performance may be less than as-new
- **Repair** - Returning a faulty or broken product or component back to a usable state; with the important rider that any subsequent warranty is generally less than that of newly manufactured, remanufactured or reconditioned equivalents and may apply only to the component that has been replaced or repaired
- **Reuse** - Operation by which a product or its components are used for the same purpose at the end of their current life.
- **Repurposing** - Utilising a product or its components in a role that they were not originally designed to perform.

These definitions bound the discrimination that we have attempted to apply to sector activities studied in this report. Notwithstanding this, *BS8887* does allow for interpretation of practices sector by sector, with a specific subsidiary definition for each. However, the *Part 2* definitions have dominance.

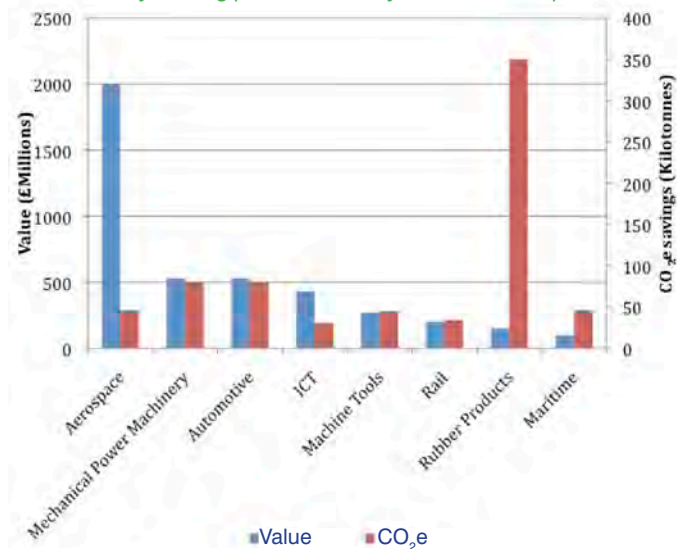


3 Previous Research

Summary of Previous Report

The 2004 survey *Remanufacturing in the UK: a significant contributor to sustainable development?*⁵ provides the only comprehensive review of UK remanufacturing and reuse activity to date. This study, conducted by Oakdene Hollins with the support of the Resource Recovery Forum, Biffaward and SEEDA, was in response to a growing awareness of the economic and environmental benefit of remanufacturing. At the time, remanufacturing and reuse were regarded as marginal activities not in the mainstream of efforts to promote business resource efficiency. However, on the basis of the report, Oakdene Hollins agitated for public recognition of the topic and gained support – initially for a pilot programme and subsequently as a main programme – from Defra via its Business Resource Efficiency and Waste (BREW) programme. Reuse as a high impact measure has been embedded in the *Waste & Resources Strategy* and, as of 2009, looks to become a significant element of the revised WRAP resource efficiency plan from 2010 onwards.

Figure 1. Comparison of value and material savings for the highest value remanufacturing product sectors from the 2004 report



A principal objective of the earlier report was to present a snap-shot of remanufacturing and reuse activities in the UK. It concluded that they were underestimated and largely ignored voices of industry. Even so, it was estimated that remanufacturing and reuse contributed £5 billion per annum to the economy, a value comparable to the higher profile recycling industry.

The survey also revealed that each year the UK remanufacturing industry saves 270,000 tonnes of materials (mostly metals) from recycling or scrapping and employs at least 500,000 people.

Benefits

The 2004 study investigated 22 sectors of manufacturing activity which were believed to have remanufacturing activity; a summary of the sectors with the highest impacts is shown in Figure 1. Of these, the aerospace, automotive and mechanically powered machinery sectors were found to have largest economic impact, contributing 40%, 11% and 11% respectively to the total remanufacturing value.

The largest materials and CO₂e savings arose from the rubber industry, mainly through tyre reuse. This sector accounted for 44% of all materials savings, though only accounting for 3% of the overall remanufacturing value. This skew in the statistics highlighted the prominence of tyres as a waste issue and the relative abundance of credible impact data. More broadly it was reported that remanufacturing and reuse led to clear but sometimes poorly recognised business benefits and resource savings across all sectors where these practices were observed.

Other non-quantifiable benefits were identified. For instance remanufacturers in the UK were often at the forefront of identifying and developing new business opportunities, and demonstrated the ability to adapt to changes in industry. Remanufacturing was found

to generate more skilful and flexible employees than equivalent primary manufacture. This workforce was able to provide goods which are the equivalents of new, but often at a much lower cost.

Remanufacturers

Remanufacturers existed across almost industrial sectors. The scale and nature of companies involved varied considerably throughout industry as a whole and typically even within sectors. The largest scale remanufacturing was operated through original equipment manufacturers (OEMs), though often the actual process was contracted out to specialist remanufacturers. This was typically a formal process, occurring on a large scale with very well established management of core and quality control systems. Other reuse options were offered through OEMs, but these alternatives were well-defined.

In addition to remanufacturing by OEMs a large number of independent remanufacturers was identified. A variation in the size of these remanufacturing businesses exists, ranging from OEM scale down to 'one man bands'. Though many produced the same quality and volumes of product as larger organisations, the more informal and localised nature of these businesses often led to lower value reuse options being favoured over remanufacture.

Barriers

Economically, the principal identified barrier was the cost to remanufacture versus the cost of new. Unless the cost of labour is low, remanufacture will be non-competitive in markets where the initial price is the principal deciding factor for purchasers – primarily due to the lower prices of new goods manufactured in other economies. Related to this, purchasers were often unaware of the long term cost and materials savings benefits that remanufactured products offered – the so-called lifetime cost of ownership.

Organisational barriers, such as separately accountable departments for purchasing and maintenance, meant that products were often bought on the basis of price. Therefore there was a perverse incentive to opt for cheaper and perhaps poorer quality new products.

Inconsistent use of the term ‘remanufacturing’ was observed within product sectors and, to a greater extent, across manufacturing industry as a whole. These discrepancies led to confusion and misunderstanding over remanufactured products. The different uses can be partially attributed to differences in product construction. However, cases were identified where ‘remanufactured’ was found to refer to any reuse type activity, and vice versa. Clarification of terminology, and proper recognition – for example by published standards – was required to distinguish true remanufactured products.

Technical barriers were also identified, including the collection of suitable quantities and qualities of core, a shortage of the correct skills, and product design leading to difficulties in sorting and disassembly. These factors exacerbate the difficulties associated with already technically challenging remanufacturing activities.

The above barriers pertained most certainly within the business-to-business (B2B) transactions, the natural domain of value-sensitive asset purchasing. Within the business-to-consumer (B2C) domain, examples of true remanufacturing were limited and largely constrained by issues of technical evolution, fashion and related sociological phenomena. For example, the remanufacture of furniture, white goods and electronics could be frustrated by an inability to cosmetically remediate, upgrade capabilities to current standards, or indeed retrieve goods in a worthwhile condition.

Consumer goods that were amenable shared characteristics of the B2B markets: functional products largely hidden from view or those providing consumable or auxiliary service strongly backed by guarantee – toner cartridges, automotive components and some electronics. Alternatively, a lower class of goods – repaired or refurbished, were marketable by the third sector purely to a disadvantaged audience.

Opportunities

Remanufacturing in the UK concluded that there was potential for far greater contributions to the economy, sustainability and resource efficiency. However, this growth was limited by economic factors which outweighed environmental concerns. Low value goods, where cheap replacements could be obtained easily, were a clear example of this issue. It was found that remanufacturers successfully operated in sectors offering high added value products, where a remanufactured item was competitively priced compared to new. Under the correct conditions and business model, remanufacturers were able flourish. Areas fitting in with these themes, but identified as having a particularly low level of exploitation, included ICT products, white goods, furniture and industrial machinery.

Opportunities also existed in areas and for products where servicing was feasible, providing motivation towards longevity, performance and durability; assets clearly aligned with remanufacturing practices.

Conclusions

The report concluded that remanufacturing and reuse had a long history and was well established within the UK. With the exception of various charity schemes the motives for operating in this area were economic and commercial.

Product Perspectives

The survey found that while many products were appropriate for remanufacture, others simply were not suitable. Therefore, several common features were identified which strongly influenced

the suitability of a product for remanufacture or reuse (see Table 1, below). These criteria simplify identification of areas of opportunity for growth in remanufacture, or may provide reasons for lack of activity in a given sector.

Industry Perspectives

In many industries remanufacturing was identified as a core activity, which supported the overall operation of the sector. However, remanufacturing and reuse often occurred out of sight and without recognition within business operations, despite the clear economic and resource benefits. It was concluded that development of the remanufacturing industry markets should not be unfairly skewed in favour of remanufacturing. Instead the elimination of the barriers to remanufacturing and reuse through various means was suggested as a more constructive pathway.

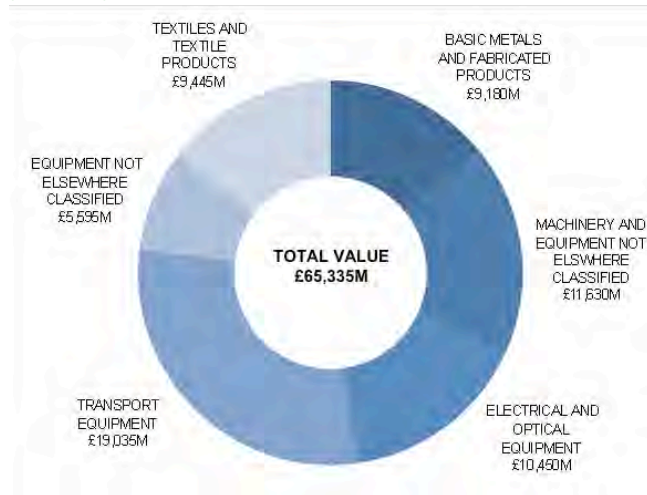
Recommendations

The findings of the previous report gave rise to a series of recommendations to sustain and develop the UK’s remanufacturing industry:

- **Supporting** existing remanufacturing efforts by raising awareness, providing coordination and development of industry wide standards
- **Understanding** the key technical, economic and social factors which have led to successful remanufacturing
- **Establishing** freedom of knowledge in product support to simplify and lower the costs of remanufacturing and aligned practices
- **Removal** of legal impediments to remanufacture which limits reuse of components indistinguishable from new
- **Research** into materials remediation. Placing figures on the environmental benefits of reuse and remanufacturing for specific products would provide a more solid demonstration of the benefits to purchasers
- **Increasing** the market for remanufactured and reused products by raising their profile through purchasing policies, education and promotion
- **Extending** product life through the introduction of better product design and longer warranties, allied with improving purchaser expectations.

Table 1. Common features influencing suitability for remanufacture	
BENEFICIAL FEATURES	DETRIMENTAL FEATURES
High intrinsic value	Poor design for assembly/disassembly
Good durability	Proliferation of materials in construction
Low to moderate technological evolution	Status-dependent, fashionable items
Core readily available	Poor perception of standards/branding
Integrated sales/service/upgrade options	Low price of new goods
Design information available	Craft skill shortage

Figure 2. Turnover of sectors most relevant to remanufacturing (£millions)



Further recommendations were made that targeted Government, RDAs, industry and other groups. These outlined a range of actions which each could commit to in order to provide further incentives and opportunities for the remanufacturing and reuse industry.

Other Relevant CRR Work

Since the 2004 report, CRR has undertaken a programme of background sector research, case studies and private work for public and private sector clients. Much of this is available on the CRR website in the publications section. It has been used substantially to create this report.

- A study for the Society of Motor Manufacturers and Traders (SMMT) in remanufacturing in the automotive after-market
- A feasibility study for Bioregional to create a business plan for the creation of construction reuse centres along retail lines, branded *Re/Y*
- Creation of the Textiles Roadmap for Defra outlining material fates including repair, reuse, recycling and repurposing
- A market analysis for the expansion of the market in refrigerated display cabinets coupled with carbon

footprint impacts

- An analysis for WRAP of the fate of used floor coverings including reuse
- Product/sector analyses for over 20 product classes surveying remanufacturing activity, trends, barriers and potentials.

4 Survey Methodology

The size and complexity of UK industry precludes a highly detailed examination of all remanufacturing and reuse activities within a single study - neither would this fulfil the objectives of this study. Therefore, a methodology was developed to reliably identify and capture remanufacturing and reuse activity at a sectoral level. This approach provided a broad but robust overview of the UK's remanufacturing and reuse industry.

Analysis of the Manufacturing Industry

Initially, an analysis of UK manufacturing was conducted using the most up-to-date (2007) annual business inquiry data available from the Office of National Statistics (ONS). No specific category exists for remanufacturing and reuse, therefore top-level divisions were identified which were known to have high relevance to remanufacturing and reuse. The total turnover for these manufacturing divisions was calculated to be £65 billion. Figure 2 (left) illustrates a breakdown of the value of these divisions.

It should be noted that the figures associated with these divisions do not provide an indication of the scale or proportion of remanufacturing within them. However, they present a useful baseline for comparison with associated remanufacturing and reuse industry activities. More detailed data allowed the identification of specific sectors with high or low turnovers within each division. This information was used to aid the evaluation of key sectors to survey for remanufacturing activity.

Selection of Sectors

To provide an accurate overview of the remanufacturing and reuse industries a group of relevant sectors was identified, using three criteria for inclusion:

- Prior indication of high remanufacturing value from previous CRR work
- Sectors identified in the 2004 survey as having potential for remanufacturing and reuse
- Sectors which did not fall into the previous two categories, but were identified as having high value in the ONS data and believed to be amenable to remanufacture.

In total, 16 sectors were identified (see Table 2) using these criteria; these sectors encompass the vast majority of remanufacturing and reuse activity within the UK.

Differences in the manufacturing and remanufacturing industries mean that these key sectors are not all individually present in the ONS's formal sectoral classifications. Also, the unique status of remanufacturing and reuse in certain sectors means its scale is not proportional to the sectoral manufacturing value. Therefore, sectors such as 'ink and toner cartridges' appear on this list but only represent a small proportion of the UK's manufacturing output and product consumption.

Sectors such as off-road equipment represent a combination of several similar product groups; these are handled together to reduce and simplify the sectoral analysis.

Surveying Procedure

Analysis of top level ONS figures (and other sources of industry information) was unable to provide a reliable indication of the scale of remanufacturing due to the limitations of the data.

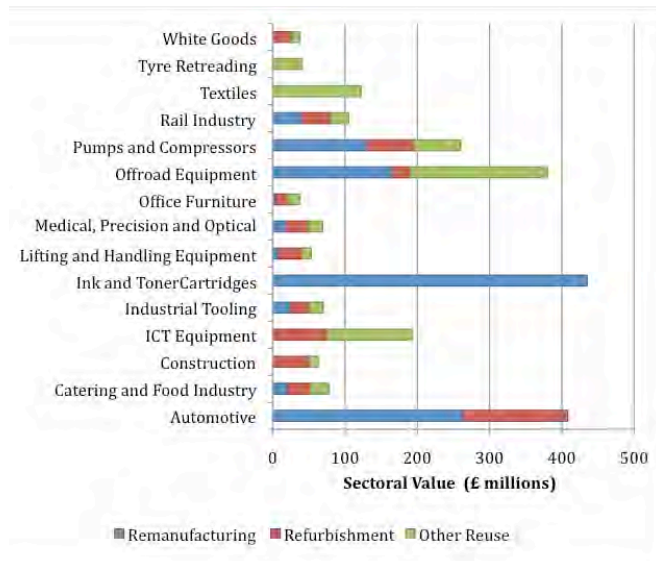
Aerospace	Automotive	Catering & food	Construction
Information & communications technology (ICT) equipment	Industrial tooling	Ink & toner cartridges	Lifting & handling equipment
Medical, precision & optical equipment	Off-road equipment	Office furniture	Pumps & compressors
Rail industry	Textiles	Tyre retreading	White goods

Instead, to analyse each sector, a bottom-up approach was adopted using information gathered through discussions with remanufacturers and other industry representatives.

A standardised but flexible approach was used to characterise each sector:

- **Defining the sector** – The products found within each sector were outlined to provide clear boundaries, and to generate familiarity of the sector
- **Background research** – Relevant information previously generated by the CRR was identified and noted. Further background data were obtained from sources such as the ONS and industrial databases. Preliminary investigations were carried out to informally gauge remanufacturing activity in the sector
- **Sectoral overview** – Relevant trade bodies and other organisations were identified and contacted to give an overview of the sector and provide possible sources of information. Sub-sectors which were thought to be rich veins were identified
- **Data collection** - A list of relevant contacts was generated from information gathered. These organisations or people were approached directly and asked to complete a questionnaire,

Figure 3. Sectoral values for remanufacturing and reuse activities



as well as contribute through less formal discussions

- **Collation and analysis of results** – All information gathered was combined to provide an overview of remanufacturing and reuse in the sector. Data were extracted and extrapolated to estimate turnovers and materials and carbon savings data
- **Partitioning of activities** - Reuse type activities were designated into three categories; remanufacturing, refurbishment and other reuse. An estimate of the scale of each was made, based on data collected.

This approach provided a characterisation of remanufacturing and reuse for each sector; these individual reports can be found in Section 6. Important and widespread features were then used to generate a snapshot of the overall status of remanufacturing and reuse in the UK.

5 Impacts of Remanufacturing in the UK

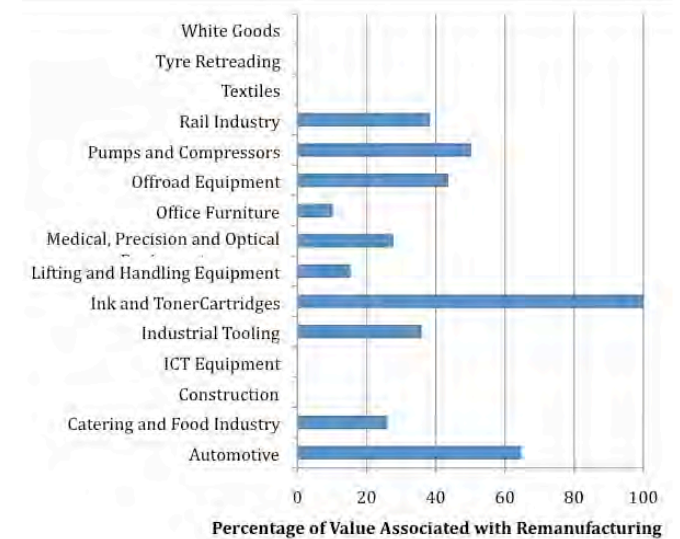
The remanufacturing and reuse industry in the UK was found to be in a healthy but potentially exposed state. The total value of these activities was assessed to be almost £2.4 billion, with the carbon savings estimated to be over 10 million tonnes CO₂e per annum*.

These findings represent a decline in the value of the remanufacturing and reuse industry in comparison with the 2004 report. However, this drop is partially attributable to the increased granularity of this survey, leading to a more accurate breakdown and a better understanding of each sector and sub-classifications of reuse. It also excludes the substantial aerospace sector, the absolute magnitude of which equals all other sectors, but which is believed to be very robust, even expanding in relative terms. With this included, activity is near previous estimates. It is included in this summary so that finer detail may be extracted.

The current economic conditions were also found to be a contributory factor. A greater than ten-fold increase in CO₂e savings is observed, primarily attributable to the low value, but high impact textile sector, which was not fully studied previously. Further analysis of these figures is provided below.

* Figures for the aerospace industry have not been calculated as they would not present a fair and accurate representation of the industry, due to its complexity.

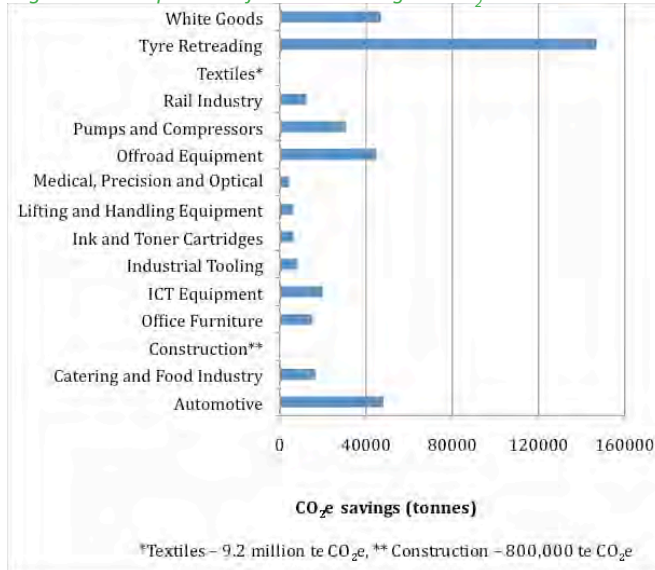
Figure 4. Proportion of remanufacturing associated with sector



Economic Significance

The combined economic value for remanufacturing and reuse in the surveyed sectors was £2.35 billion*. Comparison with the previous survey indicates that this represents a drop in estimated value of £0.65 billion since 2004, (not allowing for inflation or other factors)*. This supports the more qualitative evidence gathered through discussions with remanufacturers. However, a large proportion of this decrease can be attributed to the increased granularity of this up-to-date survey, providing finer detail of each sector.

A sectoral analysis is shown in Figure 3 (left), including a breakdown of values found for remanufacturing, refurbishment and other reuse activities within each sector. The remanufacture of ink and toner cartridges was found to provide the largest contribution to value, and shows significant growth since the previous survey (where it was included within office equipment). As found in the previous survey, other high value areas include the automotive sector, pumps and compressors and the off-road sector. Other sectors surveyed contribute modest but notable contributions to the overall value.

Figure 5. Comparison of sectoral savings as CO₂e

The information gathered allowed partitioning of remanufacture, refurbishment and other reuse activities by attributing values to these different activities for the first time. Overall, remanufacturing accounted for close to 50% of the total £2.35 billion value, with refurbishment and reuse contributing around 25% each. Within most sectors all three activities were observed, though the exact proportions of each varied greatly. A more detailed description of these variations is given within the individual sectoral findings.

Figure 4 shows the proportion of remanufacturing associated with each sector as a percentage of the sectoral value. Five sectors were found to have negligible remanufacturing activity despite having a healthy reuse market. These sectors include products such as textiles, tyres and ICT equipment which are known to favour refurbishment or other reuse activities.

The highest proportion of remanufacturing was found in the ink and toner cartridges sector, in which the total value was attributable to remanufacturing. Outside of this sector the highest proportion of remanufacturing was found in sectors which are associated with mechanical or powered machinery.

These sectors typically have greater than 30% of their total reuse value associated with high quality remanufacturing activities. As

would be expected a lower degree of remanufacturing is seen in sectors with simpler, less mechanically based products. For example, sectors incorporating electronics and electrical type products show lower levels of remanufacture despite their complexity, providing a clear illustration of the prevalence of lower value activities in these areas.

Environmental Benefits

Remanufacturing and reuse was found to save large quantities of materials and energy. For ease of evaluation these savings have been commonly expressed as CO₂e savings, calculated using accepted conversion factors.

The total savings attributed to this industry was 10 million tonnes CO₂e, a ten-fold increase compared to the previous survey.

This increase is primarily attributable to the textiles industry, which is accountable for 90% of this updated figure. This figure dominates the other sectors as textiles provide very high CO₂e savings per value compared to other materials such as steel. A similar circumstance exists in the construction and tyre industries, where a low sectoral value results in large carbon benefits.

Figure 5 (left) shows a breakdown of the individual carbon savings attributed to each sector. When the textiles and construction sectors are omitted the CO₂e savings are comparable to those found previously, albeit with a small reduction due to the lowering of background activity and value. Since the previous report a greater interest of the environmental benefits of remanufacturing and reuse has developed, though it is still irregular in certain sectors. Most remanufacturing and reuse practitioners expressed an awareness of the environmental benefits, either from a business or ethical viewpoint.

Many stated that promotion of the environmental benefits was part of their marketing and business development strategy. However, the reduction in environmental burden often remained of secondary importance when compared to other factors, most commonly the initial purchasing cost. It should be noted that while the CO₂e savings provide a reasonable basis for comparison they do represent a limited measure of environmental impact. Other factors, which may not be directly quantifiable, can be taken

into consideration if evaluating a comprehensive environmental burden. Such analysis is beyond the scope of this study, however the figures stated above give a useful indication of the benefits generated by each sector.

Other Benefits

The remanufacturing and reuse industry was also found to provide other, less quantifiable, benefits – these are broadly in line with those found previously:

- **More flexible businesses and business models** – The nature of the remanufacturing and reuse industry necessitates that businesses are more adaptable than the analogous primary manufacturers. These businesses are often better equipped than others to deal with changes in their business landscape
- **Better relationships with customers** – Remanufacturers and reusers require excellent links with purchasers in order to operate most effectively – more so than do primary manufacturers. This is commonly a result of purchasers requiring a better understanding of remanufacturing to be reassured of the quality of products offered
- **A more skilled and adaptable workforce** – The remanufacturing process requires a workforce with a high level of knowledge and skills in order to maximise the quality of their products. This typically leads to higher job satisfaction amongst remanufacturers
- **Benefits over materials reclamation alternative** – When used appropriately, remanufacturing or other reuse options provide enhanced economic and environmental benefits compared to other materials reclamation options such as recycling.

Overall Findings

Overall we conclude that remanufacturing in the UK is in a healthy but potentially vulnerable state. The headline figures point to a decline in economic value since the previous survey. This is at least partially attributable to the greater detail and granularity of this up-to-date work. However, consultation with practitioners provided important and subtle insights into the current state of the

industry which are not revealed through headline figures. These discussions indicated that the overall scale of remanufacturing and reuse was in a slight decline, particularly amongst smaller businesses. Our surveying indicates that this is linked to the waning of existing remanufacturing activities, combined with difficulties in establishing businesses in new areas, mostly as a result of the current harsh economic background.

Overarching Themes

Whilst each sector has its own individual characteristics, the most common issues influencing remanufacturing and reuse across the industry are identified below. As a caveat to these findings, it should be reiterated that the largest factor influencing the industry was the weak economic environment; this should be considered along with all these points.

- **Declining UK manufacturing base** – This has resulted in a reduction in market size for remanufactured products in many areas. Secondary consequences, including skills shortages and a decline in related industries, were also observed.
- **Availability of low cost products** – Low cost products, commonly manufactured in Asia, have reduced the demand for remanufacture for economic reasons. As the price of these products commonly competes with remanufactured alternatives, this impact is exacerbated by purchasers evaluating products on initial cost rather than overall lifetime costs.
- **Cost of labour** – The rising price of labour in the UK, particularly compared to countries where original manufacture occurs, has further reduced the economic benefit of remanufacturing. Many businesses operating under increasingly tight margins have shifted their activities towards refurbishment type work.
- **Low purchaser awareness** – Purchasers are often unaware of, or poorly understand, remanufacturing and reuse. This typically leads to misunderstandings about product quality and reduces purchaser confidence. Further difficulties arise from the interchangeable and variable use of terms within some industries.
- **Core** – The increased incidence of lower quality products has reduced the quality and quantity of core

available, further increasing the costs and complexity of remanufacturing. Existing difficulties associated with core management are also worsened.

- **Shift in favour of refurbishment** – Representatives within many industries noted that reuse had shifted away from true remanufacturing and towards lower value refurbishment type activities. This was most commonly attributed to economic pressures.
- **Longer product lifetimes** – Several cases were reported of improved product lifetimes, resulting in a decline in remanufacturing and reuse. Clearly this is likely to be beneficial from a resource use perspective; however this can also impact on remanufacturing and reuse.
- **Complexity of business operation** – Many small & medium sized enterprise (SMEs) remanufacturers stated that they were hampered by the increasing complexity of general business operation. This typically resulted in issues unrelated to remanufacturing and reuse, but still impacted on business operation.
- **Economic recession** – A variable effect on remanufacturers was noted. As stated above, overall we believe the recession has had a negative impact on remanufacturing and reuse.

Figure 6. Remanufacturing value with potential for growth

Overall potential for growth of remanufacturing	HIGH	Medical, Precision and Optical Equipment Office Furniture		Off-Road Equipment
	MEDIUM	Catering and Food Industry Industrial Tooling Tyre Retreading White Goods	Rail Industry ICT equipment Textiles	Aerospace Pumps and Compressors
	LOW	Lifting and Handling Equipment	Construction	Automotive Ink and Toner Cartridges
		LOW	MEDIUM	HIGH
Current Remanufacturing Value				



Potential for Growth

Despite the difficulties outlined above, most remanufacturers contacted at an OEM and SME level remained optimistic about the future, believing that there were strong foundations to their businesses. Indeed, segments of all sectors were identified as having potential for growth, providing that suitable conditions and incentives were present.

At a sectoral level, the potential for growth can be evaluated using factors such as product types, existing precedent for remanufacturing and the scale of activities which could be developed to remanufacturing.

Figure 6, left, compares this assessment with the reuse value found for each sector. This analysis gives an indication of which sectors could show the largest growth in remanufacturing and reuse in the future. In the short term, the absolute value of growth is likely to correlate with the existing sectoral scale of reuse and remanufacturing activity. These sectors are most likely to be accepting of these practices.

However, it is clear that there is potential for growth across a diversity of industrial sectors, which include areas where remanufacturing and reuse practices are not well established.

The analysis above provides a high level sectoral view, therefore individual subsectors are likely to show considerable variation to these overall trends: These are explored further in the sectoral findings in Section 6.

Conclusions

The information gathered during this study indicates that the UK's remanufacturing and reuse industry is in a healthy state and is fundamentally strong especially when the current economic backdrop is considered. Furthermore, we believe that opportunities for growth will arise, both in sectors where remanufacturing and reuse is established and also in new sectors. However, our findings also demonstrate that remanufacturing and reuse is vulnerable to many influences; these could hinder the potential growth.

Remanufacturing appears to be particularly sensitive to economic factors, whether these be the economic downturn, the availability of cheap goods or the varying cost of labour. Therefore, lack of short term support for remanufacturing and reuse will lead to a long term deterioration in the prospects for this industry. For example, the recent shifts from true remanufacturing towards lower value refurbishment activities should be averted to prevent longer term degradation of these activities.

We believe that the environmental benefits of remanufacture and reuse will increase their appeal in the future, as greater demands are placed on resources and as the environmental burdens of products are more widely understood. The development of the remanufacturing and reuse industry will become increasingly important if current trends in environmental legislation continue. Crucially, these changes can also be used to increase the attractiveness of remanufacturing and reuse from an economic standpoint.

Overall our findings show that remanufacturing and reuse has a crucial role to play in the future if environmental and sustainability targets are to be met. However, support is required to ensure that the industry is healthy to exploit opportunities as they arise.

Actions targeting the highlighted issues above are explored in Section 7.

6 Findings by Sector

Aerospace

The 2004 survey identified aerospace as the largest single practitioner of remanufacturing by value. In part this is driven by the inherently high value of the complex components involved (most significantly aero engines); however, this value is in no small degree due to overriding safety considerations that force complete overhaul or rotation of components and assemblies based on time in use, cycles or other measure of utilisation. By implication, the need for guarantees of safety implies that product performance is maintained at or near as-new level and this, in turn, implies that remanufacturing processes are relevant and prevalent. There is however, much terminology in the sector (commercial and military) which is bespoke and indicative of underlying product-service orientation; 'rotables', 'Total Life Management' and others.

The aerospace industry is, by the very nature of its products, a global network of suppliers and maintenance organisations. The UK industry is second only to that of the US in terms of turnover, with many of the world's leading players taking advantage of its solid base of experience and skilled labour. Turning over nearly £21 billion in 2008, the aerospace industry provides employment for 100,000 people nationwide (SBAC, 2009)⁶. There has been small growth over the last five years with a fall in civil aviation (linked to the economy) and a rise in defence turnover (likely related to Middle East campaigns). However, the pattern of commercial air travel is changing and this will affect the global stock of aircraft over the next 20 years.

Pressures on airlines and business operators to reduce the impact of aircraft on the environment are altering buying patterns. New engine and airframe technology means that today's aircraft are up to 50% more efficient in terms of CO₂ production than 20 years ago (US figures, Rolls-Royce Aviation Outlook 2005 – 2025). The recent increases in fuel price have prompted a return by many smaller operators to using more efficient turbo-prop aircraft rather than business jets.

Major commercial airlines have been keen to place orders for the

new 'mid-market' offerings from Airbus and Boeing, which provide both improved fuel efficiency and more seats per aircraft. This is set to be the fastest growing market over the next 20 years.

It is still unclear as to whether rising fuel prices and tougher environmental restrictions will mean that aircraft are retired earlier. Currently, passenger aircraft are retired between the ages of 25 and 30 years. Many then begin a second incarnation as a freighter, which may extend their working life by a further 15 years in some cases. With some aircraft still flying at the age of 40 or over, there is a huge market for overhaul and refit.

Maintenance, repair and overhaul (MRO) contributes 28% (£6.45 billion) towards the UK's aerospace turnover (SBAC, 2006)⁷. Only 27% of this can be attributed to independent service providers, with the majority of MRO activities carried out by OEMs. This trend has been developing over the past decade and looks set to continue. The engine manufacturer Rolls-Royce is one example of such an OEM. In 2005, 54% of Rolls-Royce's turnover was due to service activities rather than manufacturing (Rolls-Royce, 2006)⁸.

This is typical of industries where the operator's core business is heavily reliant upon but not directly related to, extremely complex, expensive capital equipment. The transport industry needs aircraft to move people and goods from A to B. They need reliable aircraft that are available for the maximum amount of time, and OEMs have recognised this fact by providing a service based product. It is therefore in the interest of aircraft manufacturers to design equipment that can be easily overhauled or remanufactured.



There are an estimated 2,500 SMEs operating in the UK aerospace market, with a further 2,500 larger firms (SBAC, 2005)⁹. Turnover of SMEs represents only 1.4% of the UK total. Many of these firms are involved in the overhaul of aircraft components. Whilst larger fleet operators tend to need the support of larger organisations and OEMs, smaller fleets can be maintained by these SMEs. They can also provide remanufacturing of obsolete items that are no longer supported by the OEM. So-called delegated engineering repairers (DERs) are not OEM approved, but have Federal Aviation Administration (FAA) certification to carry out such work. There is also a thriving market in non-OEM manufactured (PMA) parts, which are normally used by secondary aircraft operators i.e. those who have purchased the aircraft second-hand.

Remanufacturing in Context

The aerospace industry comprises: planes, helicopters, airborne munitions and space technology. The nature of munitions and space technology means that they are unsuitable for remanufacture, as the core are rarely recoverable. Old stocks of unused missiles and similar are sometimes remanufactured to ensure they maintain reliability, but this activity is small in comparison to other sectors.

Helicopters and planes can be broken down into a number of distinct components and systems:

- **Airframe** – This is the main structure of the aircraft that will contain all other systems. The wings, tail section, cabin and fuel tanks all form part of the airframe. Aluminium has traditionally been used for its high strength and low density, but increasingly carbon fibre is being used on not only military aircraft, but also commercial units. The new Boeing 787 airframe will be 50% carbon fibre.
- **Engine** – Aircraft engines currently take two distinct forms, gas turbine and piston driven. Piston engines are reserved for only the smallest commuter and hobby aircraft. Gas turbines make up the vast majority of the market and provide propulsion either by thrust from ejected exhaust gas (jet engine) or via a propeller powered by a compressor shaft and gearbox (turbo-prop). The engine represents by far the largest cost of

any component on an aircraft, both as a capital purchase and throughout its lifetime.

- **Avionics** – These are the electro-mechanical systems that control the plane during flight and give feedback to the flight crew. Modern aircraft contain increasingly complex technology such as ‘fly-by-wire’ capability.
- **Hydraulics** – These operate a wide variety of systems on an aircraft, from flap actuators to landing gear and cargo doors.
- **Interior** – This consists of the seats, cosmetic trim, luggage storage, galley equipment, sanitary facilities and specialist items such as medical equipment. All these items are controlled via strict regulations and approval procedures. Interiors typically contain large amounts of flame retardant material, aluminium and composites, as well as electronics and safety equipment.

The word remanufacture is not commonly used, with most companies choosing to use overhaul and component repair. In addition the term ‘rotables’ is commonly used to describe the product and service system that embeds remanufacturing and maintenance across operators from a shared pool of components. With the strict safety and quality regulations that govern the aerospace industry, remanufacture and repair amount to the same thing. To manufacture parts for aircraft requires a licence which many smaller repair and refurbishment operators do not possess; they are therefore reluctant to refer to their activities as remanufacture.

Firms that refurbish aircraft cabins regularly strip and remanufacture the interior trim and seats, repairing damaged aluminium and composite parts as required, but choose to call this ‘cabin refresh’. Engines, hydraulics and avionics all require remanufacture after a set number of operating hours or cycles (in the case of airframe components), but this is referred to as overhaul.

The aviation industry reserves the term ‘remanufacture’ for overhaul of components that have never seen active service, but are faulty i.e. as a resolution of production errors. ‘Remanufacture’ is often used by the media to describe aircraft refit. This is common in military aircraft where older models will be remanufactured to include the most up-to-date weaponry and detection systems. The word remanufacture is far more widely used in the US, where the general public is much more familiar with the term.



Evolution Rate

Evolution of aircraft technology moves at a steady pace, but introduction into the market in some areas such as airframes represents a step change. It takes years to develop a complete new aircraft such as the Airbus 380, for which development work began in 1994 and is still ongoing. Engine technology and avionics of existing aircraft may be upgraded as new innovations in efficiency and safety become available, but the airframe remains largely the same throughout the lifetime of an aircraft.

As new airframes begin to take advantage of extensive composite technology, the gains in efficiency seen by these newer models will be difficult to repeat on older stock. It is important to remember however that airlines cannot afford to completely replace their entire stock of aircraft with each innovation launched, and so it is very likely that despite the introduction of next generation airframes, older models will still be operating for the foreseeable future.

New materials technology is heavily used in the aerospace industry. Unfortunately, the advances in manufacturing are sometimes not matched by advances in repair technology. With techniques such as powder metal forming, the industry is still unclear as to whether a suitable repair technology exists, and this can limit repair to some components. Issues also exist with the inspection of certain composites for internal damage.

The possibility of fuel cell powered aircraft is now looking increasingly likely, although it is unclear when this technology will be sufficiently developed to enter commercial service. This would represent the biggest change to aircraft technology since the introduction of the jet engine during World War II, although it is

unlikely that fuel cell would completely replace fossil fuel; industry leaders such as Rolls-Royce predict strong turbo-fan and turbo-prop sales past 2020.

Reconstructability

Airplanes and helicopters are highly capital intensive machines, and as such have to be designed with a long serviceable lifetime in mind. Their design must allow for inspection and renewal of all components and systems, including the airframe. Many components are not aircraft-specific, allowing for relatively easy upgrade of avionics and the like. This makes them ideal candidates for remanufacture.

Aircraft components also hold a high monetary value and are therefore designed with repair rather than renewal in mind. Certain components have a fixed cycle lifetime after which they are considered scrap due to fatigue. Advanced non-destructive testing (NDT) techniques can be used on many items to establish their structural integrity. Components that have been retired before the end of their useful lifetime are often remanufactured and sold as spares if they pass stringent OEM-specified test procedures.

Whilst overhaul operators know that their customers cannot afford to keep an aircraft grounded for too long, they are also aware of the need to reuse parts wherever possible. Parts that will take too long to overhaul for a particular customer are replaced from a pool of identical parts that have been previously overhauled. These are known as 'rotables'. The removed part will be overhauled without time pressure, and then introduced to the rotables pool. This system means that quality used parts are always available.

Some airlines refuse to use rotables that have been used by another operator. This creates problems for overhaulers such as Rolls-Royce, who are working with customers to resolve this issue.

Trends

The remanufacture of aircraft parts and systems is an extremely well developed market, operating extensively in the UK. The strong position that the UK holds in terms of global market share means that several large firms based in Britain are leading the way in terms of both aircraft development and remanufacture.

Economics is the driving force in this highly capital intensive industry, and economics favours remanufacture as the best option for cost-effective aircraft operation. As such, it is unlikely that the UK remanufacturing market could be stimulated further by government policy.

In terms of environmental impact, the aerospace sector represents a key factor in the battle against climate change. Greenhouse gas emissions by aircraft have been identified as a growing factor in global warming. As such, the benefits of keeping 20 year old aircraft in the air are not always apparent.

Whilst remanufacture of systems for these aircraft obviously saves material resources and embodied energy, it may be more efficient in terms of life cycle energy to retire older fleets and replace them with newer, more fuel efficient aircraft.

This is not economically possible in many cases, and world aircraft production could not meet the demand to replace the entire global stock of aircraft. However, externally imposed impact constraints or the price of fuel will ultimately dictate the economics of running older aircraft and affect the move to more efficient technology.

Value

Putting an absolute value on the aerospace remanufacturing industry would require in-depth knowledge of the activities of all 5,000 companies operating in the UK. Many of these firms do not acknowledge the fact that they remanufacture components.

The Society of British Aerospace Companies (SBAC) estimates that 8% of UK aerospace turnover was created by maintenance activities. With 28% of total UK turnover attributed to MRO, this means that 20% or £4.5 billion was spent on repair and overhaul in 2005.

Some of the largest contracts for remanufacture occur in the defence sector. In 2004, after project restructuring, BAE Systems was given the go ahead to provide the MoD with 12 Nimrod MRA4 aircraft, remanufactured from the Nimrod MRA2. This contract was worth in the region of £1.2 billion (Naval-technology.com). In 2002, BAE and Rolls-Royce were



contracted by the MoD to upgrade 40 of its GR7 Harriers to GR7A standard. The work involved the remanufacture of the aircrafts' engines to provide more thrust, and was worth £150 million. Augusta Westland was awarded a contract in January 2006 to remanufacture 80 RAF Superlynx helicopters, leveraging technology from a previous £1.3 billion project to remanufacture 30 Royal Navy Merlin aircraft. Complete remanufacture of civil aircraft is less common, although not unheard of. Overhaul of engines and other systems is a scheduled activity that will occur a number of times throughout an aircrafts' lifetime, and provides a steady flow of work for remanufacturing organisations.

Aircraft also attract a limited value as scrap. The majority of the aircraft's value will be lost however if its components are recycled rather than reused. Despite the large amount of aluminium and other metals in airframes, many are simply mothballed as the process of separating out the materials is labour intensive. This will be discussed in more depth later in the report.

In the light of the high and enduring value of remanufacturing within the sector, we do not propose to skew the results of the survey with these estimates. However, we are confident that the practice is well embedded, stable and even growing, presenting a model for other sectors.

Barriers

One area that could aid the aerospace industry in achieving even greater reuse is research into advanced materials repair technology. UK universities provide an excellent source of development potential for aerospace companies seeking ways of detecting and repairing faults in high tech composites and metals. This potential

has not been ignored by the industry, and numerous joint projects are currently underway. Universities could be encouraged to create research aimed at producing technology which aids the industry, and maximises the environmental benefits of remanufacture.

Opportunities

Remanufacture is well developed within the aerospace industry. It is already recognised by users and suppliers of components and aircraft as a value adding process that can help reduce costs throughout the entire industry. OEMs in particular are becoming increasingly active in the sector, as large users of aircraft begin to switch to service- rather than product-based purchasing agreements. Rolls-Royce has entered into partnership with military and civil aircraft operators to set up and run engine overhaul centres, designed to maximise time 'on wing' by working closely with the operator.

The strict certification and test regulations governing both suppliers and service agents ensure that remanufactured goods are of an extremely high standard. Whilst many operators do not consider themselves to be remanufacturers, the high standard of their work and thoroughness of testing means that their output could be classed as remanufactured goods.

It is business need rather than environmental concern that drives the aerospace remanufacturing market. Because of the large cost



of aircraft components, operators and manufacturers alike will always consider remanufacture before new purchase. As material and energy prices rise, the cost of new components will no doubt increase still further; remanufacture will become financially viable for even more components. The drive to find methods of repairing new materials will continue to produce novel solutions, and enable remanufacture of a greater range of parts.

The need to remanufacture is also driven by the absence of cheap, competing products from the Far East as seen in other markets. Whilst there are firms, not approved by OEMs, who produce high quality replacement (PMA) parts for many aircraft systems, there are no competing budget companies producing entire systems. This means that there is often no alternative to buying from the OEM, thus remanufacture can provide real cost benefits.

The biggest challenge currently facing the industry is not that of reusing serviceable parts, but disposing of end-of-life aircraft in an environmentally responsible manner. When an airframe reaches the end of its serviceable life or is damaged beyond economic repair, it is common practice for useable parts such as engines, avionics and landing gear to be removed for remanufacture and reuse. The main hull of the aircraft is less easy to recycle however, and many airframes were simply mothballed or dumped into the sea.

Whilst there is, as yet, no end-of-life directive such as the ELV Directive in the automotive sector, manufacturers and aircraft breakers are beginning to take this problem seriously. Groups such as WingNET, funded by the EPSRC, aim to bring together interested groups from within the aerospace industry and academia to develop techniques and materials enabling recycling of current airframes, and making future aircraft easier to recycle.

Airbus is currently running a project named PAMELA (Process for Advanced Management of End of Life Aircraft) in the south of France where it aims to develop an efficient, cost effective method for dismantling and recycling of its A300 aircraft, which are now coming to the end of their operational lifetimes. Airbus estimates that up to 90% of the aircraft can be recycled or reused. In the future, the project will develop similar techniques for other Airbus aircraft. This is partly in anticipation of stricter end-of-life regulation being introduced.

Lessons from the Aerospace Sector

There are a number of factors mentioned already that make the aerospace sector unique: the stringent safety regulations governing the industry; the extreme operating environment faced by many components; the huge capital investment needed to purchase and operate aircraft, and; the concentration of the major players in the market. There are however aspects of the industry that may be transferable to other sectors, and which may aid the growth of remanufacturing in these sectors.

By recognising that customers require a service, not simply a product, aerospace OEMs are achieving improved profits for both supplier and user. The synergy between carriers such as American Airlines and manufacturers such as Rolls-Royce has demonstrated that economic gain can be achieved by designing products with many lifetimes in mind. OEM involvement gives users confidence in the quality of products, and in the support that they will receive with that product. It also enables OEMs to better understand their customers and how their product performs during service.

Traceability is a major concern in the aerospace industry. It allows individual components to have their entire lifetime documented, which means that users of remanufactured items can be confident that those items were correctly cared for in their previous lifetime. It also means that the usage of components which have a finite cycle can be monitored on the basis of hours of service, and they can be retired at the correct point, even if they are no longer on the same aircraft. Such practices could improve the perception of remanufactured goods in other sectors if a similar system of traceability were introduced.

Automotive

For the purposes of this study all motorised road vehicles from small motor bikes to HGVs have been considered within this sector – this corresponds to roughly 35 million vehicles on the UK's roads. The automotive industry is one of the largest manufacturing sectors in the UK.

In 2007 the total manufacturing and servicing activities of this sector had a turnover of £47 billion and a gross value added (GVA)

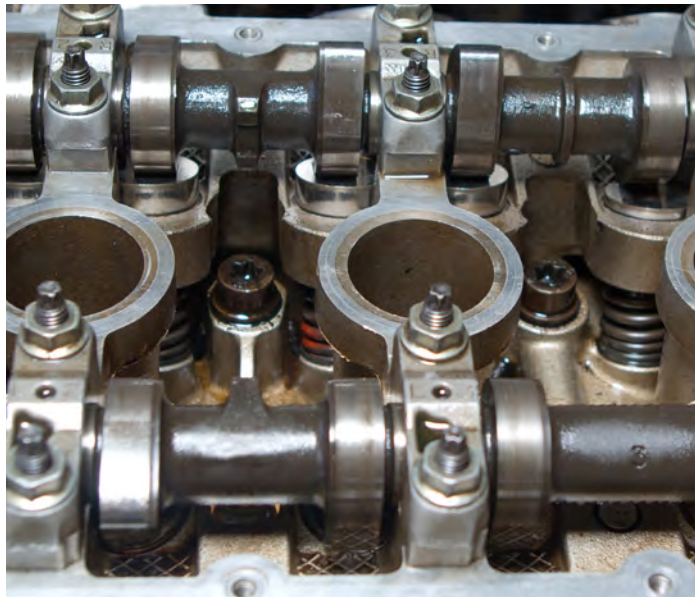
of more than £8.4 billion. These figures both rose consistently over the previous five years. Despite this growth, employment figures dropped by 25% in the same period and the total number of enterprises remained static.

Around 20 vehicle and parts manufacturers have sites in the UK. The top level vehicle manufacturers (VMs) typically operate as final assemblers, relying on a network of smaller OEMs for the production of many components. Once on the road vehicles are maintained either through approved VM garages or through the aftermarket (a network of garages and parts suppliers excluding VMs). Remanufacturing is prevalent in both of these sectors, providing a large supply of parts to support both markets.

A comprehensive 2007 report, commissioned by the Society of Motor Manufacturers and Traders (SMMT)¹⁰ and produced by the CRR, provides a great deal of detail on the automotive remanufacturing market. The information below provides a more up-to-date, but less detailed overview of the current state within the sector.

Remanufacturing in Context

The automotive sector is traditionally an area in which remanufacturing has thrived, and our findings indicate that this continues to be the case. Though remanufacturing is well integrated into the industry, few end-users are aware of its prevalence. It is therefore a good example of the transparent



integration of remanufacturing into consumer orientated services. Remanufacturing is most commonly used to supply replacement parts, either through VMs' warranty services or through the third party aftermarket. The USA based Automotive Parts Remanufacturers Association (APRA) identifies over 50 different components which are commonly remanufactured. Typically these components are of high value and require a good level of technical expertise and knowledge to manufacture and remanufacture. Despite this range of components and technologies amenable to remanufacturing, there are several overarching features of the automotive remanufacturing industry. As with other sectors where remanufacturing is common, operators in this sector can be broadly broken down into three categories:

- **Tier 1** - Large, high volume operations. Often a VM or a component OEM directly linked to an organisation requiring large quantities of parts. May operate across several countries, and may be part of an OEM's tie in to a VM
- **Tier 2** - Smaller, independent businesses providing moderate volumes of high quality remanufactured parts. These operators often specialise on a particular product or product area, and have a high level of technical skill and know-how
- **Tier 3** - Micro businesses. These typically consist of 1-5 people, and often serve niche markets. Activities range from full remanufacture, to reconditioning to brokerage activities.

Most VMs and OEMs within this industry are engaged with remanufacturing, utilising as a method for supplying warranty replacement parts. These activities are typically associated with Tier 1 operators. At this level 'remanufacturing' appears to be consistent with the definition of remanufacturing used elsewhere. Parts for the large automotive out-of-warranty aftermarket are mostly supplied by Tier 2 remanufacturers, which again perform true remanufacture. At the Tier 3 level the term is used more flexibly, and may refer to lower value reuse activities.

In addition to the remanufacturers, various specialist businesses exist to perform the complicated core management and logistics necessary to supply the remanufacturing industry. The variety of components originating from vehicles means that different

collection and redistribution procedures are required. These are typically linked to the value of the part as only highest cost parts are worth transporting long distances. For example, large engines are valuable enough to be transported long distances, and remanufacturers may supply a large geographical area. By contrast, similar long distance reverse logistics may not be economic for smaller, lower cost parts, therefore remanufacturers operate on a more localised basis.

Other variations exist in the markets for different remanufactured components; more detail about these individual characteristics is detailed in the sections below. These components were found to be either the most commonly remanufactured parts or the ones with the most potential for growth in the future.

Automotive Components

1. Engines

Engines were among the earliest automotive parts to be remanufactured, a practice originating from the first military tanks. Engines still lend themselves particularly well to remanufacturing, due to their complexity, value and function. Today, the remanufacturing of engines in the automotive industry is long established, well developed and extensive in both the private (mostly cars) and commercial vehicle sectors – around 10% of vehicles require a replacement engine during their lifetime.

The value of the market within the private and commercial vehicle sectors is roughly equal; private vehicle engines are lower in value than commercial engines but are remanufactured in higher volumes.

Remanufacturing Aspects

The remanufacture of engines occurs throughout the automotive industry. At the Tier 1 level many VMs operate remanufacturing on a large scale, either as part of their own business or through large contracted third parties. The majority of the core for these operations are sourced through warranty returns and are supplied through servicing agreements. For this activity to be worthwhile for VMs, remanufacturing must operate on a large

scale, often internationally. Only a handful of these VMs operate remanufacturing sites in the UK, and the majority of these engines are exported for remanufacture. Below the Tier 1 level the engine aftermarket is more fragmented. Several Tier 2 remanufacturers serving the automotive engine aftermarket operate within the UK market. As with the Tier 1 businesses these organisations undertake full remanufacture, and often rely on their reputation for good quality to obtain business. In addition to this, a long tail of up to 400 Tier 3 remanufacturers exists, typically 1- to 5-man bands, providing variable levels of service ranging from remanufacture down to reconditioning. These often service niche markets such as speciality or antique engines.

Our survey indicates that engine remanufacture has a value of approximately £115 million, with other associated activities at £60 million.

Trends, Barriers and Opportunities

While the operation of engines has remained broadly the same, technology has advanced significantly and engines have become increasingly complex. This is not such an issue to contracted parties as they will have access to the necessary information from the OEMs. These advances have had two impacts on third party remanufacturers. Firstly, remanufacturing engines has become more difficult due to their increasing complexity. Secondly,



engines have become more reliable, resulting in a lower demand for remanufacturing. This has led to a steady decline in third party engine remanufacturing, and this is likely to continue for the foreseeable future.

2. Drive Train Components

Remanufacturing of drive train components is a well established and high value area of automotive remanufacture. Parts falling within this category include clutches, gear boxes, differentials and axles, making it a large and diverse market. These components typically have a finite lifetime due to the strains they are placed under during normal usage.

Remanufacture extends the lifetime of the core through renewal or exchange of a few key components, while other sections of the part can be reused almost indefinitely.

Similarly to engines, the market is roughly evenly split between the high volume, lower value components for private vehicles, and equivalent but low volume, higher value parts for larger commercial vehicles.

Remanufacturing Aspects

Several Tier 1 remanufacturers operate in this industry. These are occasionally VMs themselves, but are more often contracted OEMs. Overall these activities tend to be focused on commercial vehicles as the higher value of these parts makes it worthwhile to perform remanufacture on this larger scale.

Many Tier 2 operators exist in both the private and commercial sectors, and these range in size from employing 100s down to around 10 people. One or two of the larger organisations serve a wider international market and may have some contracts with OEMs. However, most are smaller more localised businesses, providing parts for the aftermarket.

There is also a large amount less formal work performed by small third party Tier 3 type operators. The main focus of these businesses appears to be within the private small vehicle market. The standard of this work varies considerably, but the majority is more aligned with refurbishment and reconditioning than

remanufacture.

Our estimates place the value of the market for fully remanufactured components at £65 million, with the variable activities of the Tier 3 operators contributing a further £60 million.

Trends, Barriers and Opportunities

The outlook for this sector of automotive remanufacture appears to be variable; overall the scale of this subsector has remained relatively constant since the previous report. There are and will continue to be a number of factors which influence this:

- **More complicated technology** – This increases the complexity of remanufacturing, but makes it possible to keep up with advances through R&D investment. However, the increased value of these parts increases the viability of remanufacture.
- **Increased longevity of parts** – This reduces the level of remanufacture occurring as there are simply fewer parts requiring replacement. This also reduces the availability of core.
- **Cheaper, copied parts** – A steadily growing factor as a greater number of parts become available. This appears to have influenced the private vehicle market and particularly the Tier 3 remanufacturers the most, due to the lower price of these parts and services.

Within the industry some businesses are optimistic and are seeking to expand, some are seeing a steady decline and others have stopped remanufacture completely. Overall, it appears that the scale of this sector will remain fairly constant or in slight decline.

3. Rotating Electrics and Ignition Parts

The rotating electrics sector includes alternators, dynamos, starter motors and ignition coils used in all types of vehicle. Historically these parts have been an area of high activity within the remanufacturing industry.

These components most commonly consist of an outer casing, and an internal section consisting of magnets, brushes and a wound copper wire solenoid. Typically remanufacture involves reusing

the outer casing and brushes, and rewinding the solenoid and replacing other parts as necessary. This can be a relatively labour intensive process considering the low cost of a new part, therefore high volume processes are the most economic.

Remanufacturing Aspects

There is no evidence of OEM or VM remanufacture occurring in the UK. Some remanufacture occurs abroad; however, the tight profit margins associated with this activity indicates that international export from the UK is likely to be a marginal activity. Instead it is more common for VMs to supply new parts as replacements.

A handful of large Tier 2 remanufacturers operate in the UK, working independently from OEMs. These support the aftermarket, supplying national parts distributors and garages. A large range of 2000+ products is offered by these operators corresponding to the vast array of different vehicles on the road.

The remanufacturing sector underneath these large operators consists of a long tail of smaller businesses, supplying localised markets. These businesses typically offer remanufactured products, however some reconditioning and rebuilding services at a lower quality and value also occurs.

We estimate that remanufacturing of rotating electrics contributes around £50 million, with the other, lower value reuse aligned activities contributing roughly £10 million.

Trends, Barriers and Opportunities

The increasing quantity of low price imports has had the largest impact on this industry as these can directly compete on price terms with remanufactured parts. This, combined with the relatively low value of each item, means that remanufacturers in this area are particularly sensitive to the cost of labour.

These factors have caused some well known remanufacturers to go out of business. However, this has allowed surviving businesses to become more established, and these organisations have grown to fill the market. The overall market for remanufactured rotating electrics is relatively static as the longevity of these parts is slowly improving but the number of vehicles on the roads is increasing.

Further into the future, opportunities may arise as the number of operations performed by electric motors in vehicles increases – a modern car may have upwards of 100 of these motors. Remanufacturing may become viable if these become common and valuable enough.

4. Turbochargers and Superchargers

Turbochargers (turbos) and superchargers are used to increase engine power by forcing air into an engine during the combustion cycle. In the past these components have been associated with specialist uses such as high performance racing cars. More recently, the use of turbos has become far more widespread than superchargers, with turbos now fitted to most diesel engines in private and commercial vehicles to improve performance and efficiency.

These components function by either using a turbine spun by exhaust gases in the case of turbos, or by using a small proportion of the engine's power output in the case of superchargers. To run most efficiently they must spin at 15,000 rpm or faster. Reliably operating at these speeds requires high build quality and fine manufacturing tolerances.

This complexity is reflected by the limited number of manufacturers; globally there are three or four companies that supply about 85% of the market. Though turbos and superchargers are reliable, the high stresses put on these parts mean that they are liable to fail, providing an opportunity for remanufacturing both as warranty replacements and in the aftermarket.

Remanufacturing Aspects

Remanufacturing in this sub-sector is mostly limited to turbos as they are more common. The high value, complexity and stresses placed on turbos mean they are ideal for remanufacturing. These factors, combined with their growing usage have provided an opportunity for remanufacturers in this sector.

However, technical knowledge is essential for these activities, therefore high volume remanufacturing is performed by OEMs or contracted/approved third parties. There are around 10 of these remanufacturers servicing this bulk market in the UK; these

companies are fairly secretive due to the sensitive technical knowledge involved.

A group of smaller remanufacturers also exists which are not directly linked to an OEM, though they may specialise in a specific brand. Typically these organisations service smaller, niche markets such as motorsports. However, these businesses still perform high quality remanufacture as this essential for these parts. There is no evidence of lower level refurbishment or reconditioning for these parts, most likely due to their technical nature and precise working tolerances, making these lower value activities less technically viable.

Our survey indicates that remanufacturing of turbos has a value of £15 million in the UK. There is very little low level reconditioning due to the nature of the parts, therefore no estimate of this is made.

Trends, Barriers and Opportunities

The outlook for the remanufacturing of turbos is mixed. Turbos are likely to become more common in vehicles as technological improvements allow increased performance, efficiency and reliability. It is likely that more turbos will be available for remanufacture, despite their increasing longevity.

However, turbos are becoming increasingly complex, and the introduction of technology such as variable geometry inlets is reinforcing the need for remanufacturers to be involved with an OEM. Therefore, remanufacturers with established links to OEMs are likely to see an increase in remanufacturing volume, and these will be the exclusive operators in the bulk market.

For other organisations this growth will be held back by restricted access to technical knowledge. For this reason only specialist and niche markets will be open to smaller remanufacturers.

5. Air Conditioning

Air conditioning, which was once restricted to the most expensive vehicles, is now available in the majority of new vehicles sold in the UK. VMs consider air conditioning an essential option for all but the most basic of vehicles and presence or lack of it also influences the resale value of vehicles.

As with other common chilling systems, automotive air conditioning units consist of a compressor, a radiator, an expansion valve and an evaporator. The similarities to other heating, ventilating and air conditioning (HVAC) systems, and their increasing prevalence in vehicles, have provided an opportunity for remanufacturers.

Remanufacturing Aspects

Remanufacturing of air conditioning systems is less well established than other areas of automotive remanufacture. This can be attributed to the relatively recent growth in use of this technology. It is also distinctive from other areas of automotive remanufacture as the parts have more in common with HVAC systems than other automotive components.

The most commonly remanufactured part is the compressor, as this is one of the higher value components and is most likely to wear out. Other parts, such as the radiators, are more likely to undergo refurbishment type work. At present it appears that VMs are not involved in any of this activity, and work is mostly performed by independent third parties on a relatively small scale. However, there is large potential for this sector to expand in the future.

We estimate that remanufacturing of air conditioning parts accounts for around £5 million, with lower value reuse aligned activities contributing roughly £5 million.

Trends, Barriers and Opportunities

Several factors are likely to influence this market in the future:

- **Non-essential function** - While air conditioning is often considered essential when purchasing a new car, it is not critical to the running of a vehicle. Therefore, it is less likely to be repaired than other more critical parts.
- **Skills** – Air conditioning units are different from many commonly remanufactured automotive parts, therefore current remanufacturers are unlikely to have the correct skills to remanufacture these parts. However, collaboration with remanufacturers in the HVAC sector may allow progress in this area.
- **Technology** - Currently there is a trend for air conditioning to move towards more complex 'climate control' systems,

providing a greater degree of environmental control within vehicles. These are incorporating an increasing quantity of electronics and plastics which increase the difficulty of remanufacturing.

While remanufacturing and reuse of these components is currently at a low level, the increased number of vehicles fitted with air conditioning and the similarities between other HVAC systems indicate that there is plenty of potential for growth.

6. Electronics

The role of electronics systems in vehicles has developed enormously since their comparatively recent introduction. Electronic systems are increasingly necessary for managing vehicles' operations through components known as electric control units (ECUs), and these are now used to control sub-systems such as engine management, traction control and airbag deployment. It is estimated that approximately 10-15% of a modern car's value is associated with these electronic systems. ECUs are the main focus of electronic based remanufacturing activities.

Remanufacturing Aspects

Research suggests that the remanufacture of ECUs in the UK is largely a third party activity undertaken by Tier 2 and 3 remanufacturers, which supply specialist trade garages. It appears that the majority of OEMs and VMs do not undertake remanufacture of these components (it was previously stated, however, that one or two OEMs do remanufacture electronics outside the UK on a limited scale). Instead, new components are favoured as replacements over any form of reuse. Furthermore, it was suggested that in certain cases OEMs may offer 'remanufactured' ECUs which are simply rebadged new components – arguably this could be an attempt by OEMs to increase the availability of core.

Within this independent sector the most commonly remanufactured component are the engine management ECUs. There are two reasons for this: firstly, engine management ECUs were amongst the first type of electronics to be introduced into vehicles, so remanufacturers have had time to gain an understanding of how they operate and how they have developed. Secondly, there are additional issues associated with the remanufacture of other ECUs,

for example safety concerns around the remanufacture of air bag electronics and obvious difficulties with operations on alarms and immobilisers.

To date, the scale of this industry has been limited due to difficulties in the remanufacturing process. A few, well established Tier 2 electrical remanufacturers exist in the UK. Over time, these companies have developed a good understanding of the processes required, and are able to adapt to changes made by OEMs. We estimate that the value of this market is worth around £3 million in the UK. There is also evidence of a variety of other activities occurring below this level; gauging this impact is difficult due to the localised and informal nature of this industry.

Trends, Barriers and Opportunities

Despite the difficulties associated with remanufacturing these components, the general belief was that as electronics become more common in cars and ECUs are better understood, remanufacture could expand within the independent sector. There are two significant barriers to expansion in this area:

- The limited amount of information available to third parties about these components, which restricts the work that they can perform.
- VMs and OEMs are not as involved with remanufacturing for electronics as they are with other automotive components.

Remanufacturing these items requires specialist knowledge, which is often outside the skills of more traditional remanufacturers. The 'black-box' nature of these components adds to the complexity of



this process; successful remanufacture is often reliant on building up knowledge over a period of time. Specialist equipment is also required, especially for running diagnostics and testing of components. Third parties are also hampered by the design of ECUs, which often contain features specifically designed to prevent extensive remanufacturing or tampering. Therefore, there may be an opportunity for existing remanufacturers to engage with OEMs and VMs to open up the market to the benefit of both parties.

7. Remanufacturing of Other Components

Within the automotive industry, remanufacture occurs on almost all high value components to some extent. Those outlined above form the majority of components which are remanufactured on a large scale or appear to have the greatest growth potential. Below this level many other parts such as water and fuel pumps, HGV air brakes, fuel injectors and distributors are remanufactured in medium to low volumes.

These parts are often cheap and easy to replace, typically making large scale remanufacture unfeasible. For the lowest volume parts small scale remanufacture is often possible due to parts going out of production or niche markets. These situations provide some opportunity for a limited amount of remanufacture in this area, and a few smaller Tier 3 remanufacturers exist in these areas. In certain cases, parts such as brake callipers form a small part of a larger organisation’s overall business. We estimate that these Tier 3 remanufacturers have a turnover of £20 million in total for combined remanufacturing and reconditioning activities. Based on information provided from the industry likely areas of growth in this area are brake callipers and fuel injectors. Remanufacturing of other parts was predicted to remain constant or in gradual decline.

Overall Trends and Values

We estimate that the entire automotive remanufacturing industry and aligned activities within the UK is worth £408 million. The contribution from each of the major remanufactured component groups is summarised in Table 3. The overall materials savings from this sector were calculated to be 27,200 tonnes steel equivalent (or 48,144 tonnes CO₂e). These figures represent a decline since the previous survey was undertaken. This is partially attributable to the re-categorisation of certain products into other sectors. However,

a drop in reuse in the two largest subsectors has occurred, resulting in an overall drop in the sector.

Barriers

It is clear that the nature of different parts will strongly influence the future extent of their remanufacture; these have been discussed above where relevant. There are also a number of wider issues which will influence the overall remanufacturing industry:

- **Costs** - A major recent influence was found to be the rising cost of labour in the UK combined with the falling price of new components. This has lowered the viability of remanufacture, particularly where price margins are tight.
- **Technology** - Advancing technology, particularly electronics, has resulted in parts becoming more complicated. Typically this has increased the difficulty of remanufacture, and it is necessary for remanufacturers to invest increasing resources into R&D to keep pace with this development. Remanufacturers are required to learn new electronics based skills in order to remanufacture ostensibly mechanical parts.
- **Core management** - As is the case with other sectors, core management was found to be a key issue for remanufacturers operating at all levels. A variety of businesses from the Tier 1 to the Tier 3 level stated that growth has been limited by the number of core that could be obtained.
- **Economy** - The contracting economy has had a variable impact on remanufacturers. Some remanufacturers have suffered, many going out of business due to poor sales.

This may be linked to the component types, as users are more likely to have a critical component replaced, such as the starter motor, than a less vital part such as air conditioning. However, others have reported an increase in business due to customers seeking lower cost options.

- **Car scrappage** - The ongoing car scrappage scheme has had a negative impact on remanufacturers involved in car parts, particularly those operating in the aftermarket. This scheme has encouraged consumers to replace older cars rather than repair them, reducing the quantity of parts required. However, this process also requires that the cars are completely scrapped, thus limiting the number of core available to remanufacturers now and in the future.
- **Skills shortages** - The decline in remanufacturing caused by other factors has had the secondary effect of producing a skills shortage, as fewer people are developing the skills to remanufacture. This is perceived as a major long term problem within the industry.

Opportunities

Remanufacturing is already a core part of the automotive industry and will continue to be so into the future. However, our report indicates that a reduction in value and volume has taken place since the last survey, and therefore measures should be taken to ensure that it is maintained at a high level. A number of opportunities exist to aid this. Several automotive systems, including turbos, air conditioning and ECUs, are becoming more common in modern vehicles. Extension of remanufacturing practices in these areas could present significant opportunities for VMs and remanufacturers if they position themselves correctly.

Table 3. Value of UK automotive remanufacturing and aligned activities

COMPONENT	TOTAL REUSE (£MILLIONS)	REMANUFACTURE VALUE (£MILLIONS)	OTHER REUSE VALUE (INC. REFURB) (£MILLIONS)	CURRENT TREND
Engines	175	115	60	Decrease
Drive Train	125	65	60	Plateau/Decrease
Rotating electrics	60	50	10	Plateau
Turbo and Superchargers	15	15	---	Increase
Air Conditioning	10	5	5	Increase
Electronics	3	3	---	Increase
Other	20	10	10	Plateau
Overall	408	263	145	Decrease

Vehicles have longer lives, and the average age of vehicles on the road is now over seven years; this has been gradually increasing. This should provide an opportunity for the remanufacturing sector as a whole as it is likely that more spare parts will be required.

The EU's end-of-life vehicle (ELV) legislation could buoy the remanufacturing industry in this sector. Historically, the automotive industry has demonstrated a high degree of reuse and recycling. New regulations are gradually increasing this level from 75% 10 years ago up to a target of 95% in the near future. Remanufacturers may be able to take advantage of this by providing alternative and superior reuse options for the industry.

Catering and Food Industry

For simplicity, this sector has been further divided into three subsectors, excluding large scale production machinery.

General Catering Equipment

Within the UK there are over 250,000 food outlets which each year produce almost 9 billion meals per annum with a combined value of £40 billion. The largest caterers within this industry are pubs, restaurants, prisons, hospitals and hotels.

Catering equipment in this sector is needed for tasks such as cooking, refrigeration, washing and hot beverage production. The scale of the catering industry means there is a substantial market for equipment purchasing, servicing and spares; these combined have a total value of £1 billion a year in the UK. Two thirds of this value is associated with equipment purchasing, corresponding to around 1 million pieces of equipment.

The majority of catering equipment is bought new through dealers or direct from the manufacturers. OEMs tend to specialise in specific types of catering equipment, and there are several well known brands for each equipment type. Most catering equipment is built to last as it will normally experience heavy use. With the correct servicing and repairs this equipment will have a long lifetime of many years. Due to its low inherent value at end-of-life, catering equipment is most likely to be scrapped rather than potential life extension options being taken.

Refrigerated Display Cabinets

Refrigerated display cabinets (RDCs) are devices that enable the sale and storage of chilled and frozen food and beverage products in a retail environment. They are common to all supermarkets and convenience stores selling chilled food; 630,000 are currently installed in the UK. RDCs serve two purposes: to ensure that the produce sold is fresh and to enable the customer to view produce prior to selection.

The design, shape and size of RDCs can vary greatly depending on their specific use, but all operate in one of two ways. Integrated models contain compressors and heat radiators within the unit, much like a domestic fridge. Remote units are not supplied with a compressor or heat radiator. Instead coolant for these units is provided from a compressor which provides coolant to several remote RDCs. These are more suited to sites which have a large number of RDCs in operation, typically supermarkets.

A variety of companies manufacture RDCs and sell them directly to users. Most OEMs are based outside the UK, and increasingly the market for RDCs has been under pressure from manufacturers offering cheaper, but lower quality units.

Vending Machines

Vending machines provide access to goods at wider variety of locations than is possible through traditional retail outlets. The huge growth seen in this sector has been driven by the increasing desire for reliable access to goods. Many products are now available through vending machines, but typically the merchandise is associated with impulse purchases.



By far the largest market is the sale of refreshments; in the UK this market is worth around £1.5 billion a year. There are now 420,000 refreshment vending machines in the UK to support this demand, which, to give an indication of the scale of the industry, dispense 8 million cups of coffee per day.

A variety of specialist OEMs manufacture the different types of machine required within the sector. In the past these have been mainly UK or Europe based. More recently units constructed in the Far East are becoming common as their lower initial cost appeals to equipment purchasers.

New vending machines may be sold outright to operating sites, though more commonly a third party purchases the machines and sets up leasing agreements with operating sites to supply the machine, goods and servicing. Different leasing and management arrangements exist dependent on the type of goods sold and expected sales volumes.

Most vending machines will be kept running for as long as is economically possible, though they may be moved to a site where aesthetics and function are less important as they becomes older. At end-of-life most vending machines are scrapped and materials may be recycled by operators. Some parts may be salvaged for spares to use for the maintenance and repair of other machines.

Remanufacturing in Context

General Catering Equipment

Our survey indicated that there is little true remanufacturing occurring within this sector, however refurbishment and reuse is relatively commonplace. Remanufacturing appears to have little meaning within the industry. A minority of representatives indicated an awareness of remanufacturing; however they clearly stated that it was not well understood in the industry. The lack of remanufacturing activity in this sector can be explained by attitudes within the industry, the relative costs associated with remanufacturing and the simple design of much of this equipment; these barriers are explored further below.

By contrast, an active used market has evolved for most equipment

types, and equipment is routinely refurbished to supply this market. Instead of end-of-life, the primary sources of items are through kitchen refurbishments, changing catering requirements and outlets closing down. Varying levels of refurbishment are performed before items are sold on - the use of this term typically indicates aesthetic changes rather than more rigorous and substantial work.

Refrigerated Display Cabinets

A previous report by the CRR¹¹ has outlined the current remanufacturing activities in this sector. It was found that remanufacturing is reasonably well understood in the industry; however, this awareness did not always penetrate larger organisations such as supermarkets. Some discrepancies were also found in the services which ‘remanufacturers’ offered. The quality of this activity was often consistent with true remanufacturing, however many operators have used ‘remanufactured’ to describe goods which would be more accurately described as refurbished. This non-standard usage often leads to purchaser uncertainty or mistrust.

RDCs are ideally suited to the remanufacturing process. The external shell of an RDC can last several remanufacturing cycles, with modifications made as necessary. At the same time internal systems can be upgraded to meet current energy efficiency specifications. (It should be recognised that the majority of the carbon footprint from an RDC is derived from its use phase, mainly through the use of power for cooling).

The typical lifetime of a unit is five to eight years; with remanufacturing this lifetime can be extended two- to three-fold.



One of the largest RDC remanufacturers in the UK is The Bond Group, which annually remanufactures around 4,000 RDCs, or approximately one third of the overall remanufactured and reused RDC market. Besides these, lower quality refurbishment is evident, but this has sometimes been mis-sold as remanufacturing leading to a devaluation of the term.

Vending Machines

The use of the terms ‘remanufacturing’ and ‘refurbishment’ within the vending machine industry is consistent with other industries where these activities are well established and understood.

Vending machines comprise an outer casing constructed of metal and wood which is relatively simple to refurbish or remanufacture. Internally they are more complex, often containing electronics which are required for processing payment, storing and dispensing products. More specialist machines may require chilling or heating units, which are often the least reliable components.

This construction lends itself moderately well to remanufacture, and historically several companies have successfully remanufactured this equipment. However, this remanufacturing work is limited to independent third parties, and no OEMs were found to offer remanufactured products. Refurbishment is relatively common and this activity is usually to upgrade aesthetics, which are of importance for this equipment.

Leasing companies typically offer agreements which are shorter than the lifetime of machine, providing an opportunity to repair machines out of use.

Trends

General Catering Equipment

The scale of remanufacture, refurbishment and reuse has remained constant within this industry over the past few years. Although the availability of used equipment has risen recently due to businesses closing down, there are fewer outlets seeking to buy equipment.

This situation is likely to continue into the future. Similarly the proportion of full remanufacture is unlikely to increase as most equipment is not sufficiently complex or of high enough value to warrant it.

Refrigerated Display Cabinets

We have estimated that around 11,000 RDCs were remanufactured or refurbished in 2008, corresponding to 11% of RDCs which were replaced. This proportion suffered a large decline in years prior to 2005, but has increased again since.

Based on current trends, the size of the remanufacturing market is predicted to remain stable as the proportion of remanufacturing will decrease, but the number of RDCs requiring replacement will increase.

Vending Machines

The current trend for remanufacturing and reuse in this sector is downward, though historically these activities have been relatively common. The price of new equipment has fallen due to cheaper imports from outside the EU; this has made remanufacturing

Table 4. Value of general catering equipment recovery sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
21	1	10	10	2,527	4,473

Table 5. Value of refrigerated display cabinets recovery sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
40	17.5	17.5	5	4,814	8,520

Table 6. Value of vending machine recovery sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
16.5	1.5	5	10	1,986	3,515

based activities less viable. A number of operators reported that they have had to adapt, and have shifted their business focus from remanufacture to refurbishment.

Values

General Catering Equipment

Within the catering industry most pre-owned equipment is sold site to site as seen or through brokers after being cleaned up (though not always), therefore reuse is more prevalent. Due to the significant number of informal sales gauging the size of the market is difficult; we estimate that other reuse and refurbishment activities are worth around £10 million each (see Table 4). A much smaller proportion undergoes more extensive remanufacture work, replacing parts and testing. This equipment is typically sold for 50% of the new price.

We estimate the total value of this market to be £1 million. The majority of reused equipment is constructed from stainless steel, and because of the small market size the materials and carbon savings are relatively modest compared to other sectors.

Refrigerated Display Cabinets

The total reuse market for RDCs is estimated to be worth £40 million (see Table 5). Approximately £5 million is associated with low value activities; the remainder is equally split between remanufacturing and refurbishment activities. Materials savings are estimated to be around 6,000 tonnes, mostly from steel. This corresponded to carbon savings of 20,000 tonnes CO₂e. These values do not account for the energy efficiency upgrades included in the remanufacturing process.



Vending Machines

Most reuse type activity occurs through the ongoing repair and maintenance of these machines, as described above. Outside these activities we estimate that related independent third party activities have a turnover of around £16.5 million with full remanufacture accounting for £1.5 million of this value (see Table 6). This represents a small proportion of the total vending machine market.

Barriers

General Catering Equipment

Three main barriers exist to remanufacturing in this sector:

- **Equipment** - Much of this equipment is relatively simple and cheap to produce, and refurbishment is enough to extend its lifespan almost indefinitely. This favours reuse and refurbishment over remanufacturing. More complex equipment including hot beverage machines or industrial fridges may offer opportunities for aspects of remanufacture, though other factors inhibit this.
- **Cost of remanufacturing** – Despite being relatively simple equipment the cost of remanufacturing often precludes it as a purchasing option. Purchasers of pre-owned equipment are more content buying pre-owned refurbished equipment at a lower price than a higher cost, remanufactured item. Comparison with the new equipment market indicates that remanufactured alternatives do not fare well as purchasers favour buying new equipment. This is further reinforced as many pieces of equipment will cost the same to buy new as they would if remanufactured.
- **Attitudes** - As remanufacturing is poorly understood in this industry, purchasers are unwilling to consider remanufactured items even if competitively priced.

Refrigerated Display Cabinets

- **Low cost imports** - The use of low cost new RDC imports has eroded but not obviated the cost advantage of

remanufactured goods. The quality of these imports is typically lower, so this has a secondary influence of providing fewer suitable core for remanufacturers.

- **Purchasing attitudes** - A whole life cycle view which can be an incentive to value the longevity of the products is largely absent amongst RDC buyers. However, purchasing structures within retailers frequently favour a 'cheapest is best' choice. This is despite the fact that the cheapest new RDCs will often cost more over their lifetimes due to poorer energy efficiency or premature failure.
- **Perceived quality** - A poor reputation is largely earned as a consequence of some disreputable remanufacturing practices, with true remanufacturers often relying on their reputation with particular individuals within the buying departments of retailers to make sales.

Vending Machines

Low cost imports are the main factor restricting remanufacturing in this market; this has had two impacts. On a fundamental level, remanufacturers are simply unable to compete with the prices of new products; therefore it is not worthwhile to remanufacture these machines.

There is also evidence that these low cost vending machines are made of poorer materials, therefore the core quality is lower, and remanufacturing more difficult. Technological advancements also increasingly influence remanufacturing and refurbishment. Vending machines are becoming increasingly complicated and investment in innovation in this sector is relatively high as the market is quite profitable.

Recent advancements include introducing debit and credit card purchases enabled by wireless telemetry and the installation of lasers to ensure that a product has correctly been dispensed. Off-grid vending machines with fuel cells have been developed which are powered by replaceable hydrogen storage tanks.

This development has made it tough for remanufacturers to keep up with the technology in cutting edge machines. This problem is amplified by the lack of OEM engagement, and there is very little incentive for them to design with reuse mind.

Opportunities

General Catering Equipment

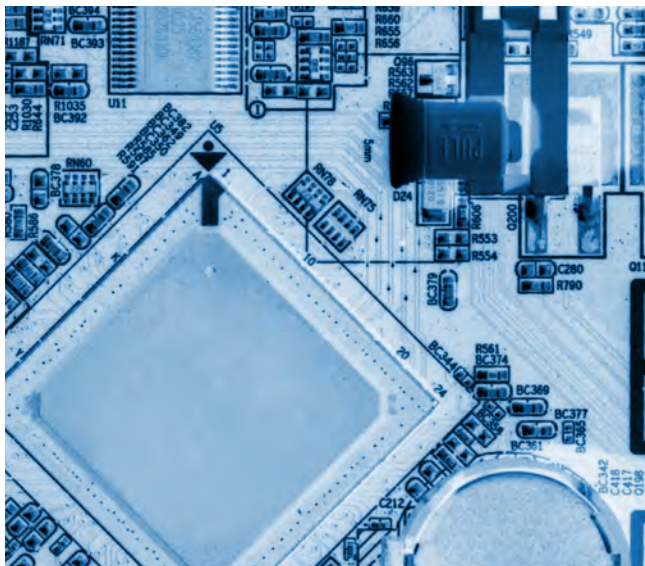
Despite the low level of remanufacturing occurring within this sector other aligned activities are more common, and potential opportunities include:

- **Reuse and refurbishment** which are already reasonably well established in this sector, therefore there is potential to stimulate growth by increasing awareness of the availability of these products. More serviced business models such as equipment leasing could be offered to allow growth in this side of the industry.
- Possibly increased scope for the **remanufacture** of certain equipment, particularly refrigeration and chilling equipment as there is precedence for this in the HVAC sector.

In contrast to economic factors, there was little evidence for environmental considerations being taken into account with catering equipment purchases. Increasing the industry's awareness of these benefits may help increase the level of reuse, and help develop a market for remanufactured products.

Refrigerated Display Cabinets

The current level of remanufacturing and reuse and potential size of the market suggests that there is an opportunity to increase the level of activity for RDCs.



This could be maximised by:

- **Engaging and educating retailers** on the benefits of remanufacturing, including the environmental aspects.
- **Evolving remanufacturers** into service-led businesses with expanded ranges of options for purchasers including leasing both new and remanufactured RDCs.
- **Adoption of standards and industry-wide good practices** to increase purchasers' confidence in true remanufactured products.
- **Formation of partnerships** between OEMs and remanufacturers to benefit the business practices of both parties.

Vending Machines

The levels of remanufacturing seen in this industry in the past would indicate that there is some potential for the regrowth of remanufacturing and reuse practices.

Remanufacturers stated that improving the awareness of opportunities for larger organisations which use vending machines could help boost remanufacturing, particularly as the benefits may fit in with various sustainability and social responsibility targets. The development of alliances between OEMs and remanufacturers could increase the value of both business aspects. The implementation of standards and guidelines within the vending machine industry would ensure that remanufacturing and reuse activities are consistent throughout the sector, providing purchasers with more confidence in these options.

Enforcing regulations which increase the build quality of these machines by eliminating poor quality materials would provide remanufacturers with a better supply of suitable core. This would make the remanufacturing process easier and cheaper.

Construction

The construction sector is one of the Government's priority areas for sustainable production and consumption. Primarily, this is because of the large impact that buildings in use have on CO₂e emissions through heating. However, the resources, and

carbon impact of manufacturing them, are not insignificant with, for example, cement production being highly energy intensive, growing in line with population and GDP trends worldwide.

However, concentration on individual materials in this way is misplaced and can lead to ill-informed decisions. Construction itself embraces an incredible diversity of materials, products and construction systems; genuine comparisons of net impacts – as when considering other sectors such as transport – must therefore involve the full range of life cycle impacts: manufacture, use and end-of-life. This is exacerbated by the complexity of supply chains, skill levels and relative disconnect between end-of-life and design, which may be separated by decades.

Remanufacturing in Context

To all intents and purposes one may assume that remanufacturing – as defined in this work – is not practised to any significant extent in the UK. The ability to reclaim complete usable systems is beyond the capacity of most demolition companies. In addition, it is highly likely that products of sufficient complexity to justify remanufacture will have seen significant technical evolution over their anticipated life, making them incompatible with fast-evolving buildings standards. There is, however, a significant market for certain reclaimed products of architectural and historic significance such as sash windows. These have proved highly durable and can be cost-effectively reconditioned by repair and replacement of technical elements, and sometimes upgraded by the addition of, for example, double glazing. Straightforward reuse undoubtedly represents the one of the greatest opportunities in construction. The use of doors, door and window furniture, frames, flooring, ducting, tiles, bricks etc. is a substantial and recognised element. Such products can be utilised with relatively little modification or further work.

A final significant yet under-exploited element is that of redeployment. Some elements of buildings offer the potential for reuse in a modified size or shape, but are typically sent directly to recycling. This includes steel beams and structural timbers. The necessity for speed at the demolition stage usually means that these do not receive the favourable treatment, inspection and verification necessary for reuse.

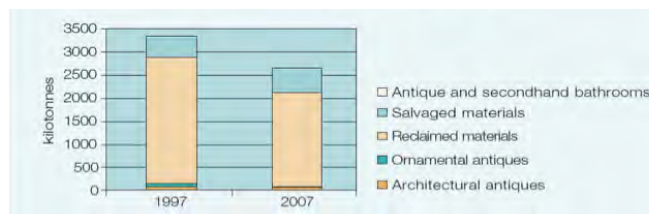
Trends

Reuse in the construction sector has long been associated with salvage and, in particular, the recovery of architecturally or aesthetically desirable objects: Doors, windows, tiles, slates, flags, bricks, lintels, radiators, fireplaces, ironwork, door and window furniture, sculpture and other objects.

More recently, with Government initiatives to reduce landfill spearheaded by WRAP, the construction industry has been targeted with initiatives aimed at supply-chain waste elimination off-site and on-site, segregation of waste at source during the construction phase, and segregation of wastes during demolition. This initiative has been a resounding success. Unfortunately it has been to the detriment of the other reuse activities.

A comprehensive sector strategy review produced by BRE and AEAT in late 2006¹² quantified the lost potential. This was further quantified by a subsequent industry roadmap published by the Construction Resources & Waste platform (BRE-led) in 2008¹³. Figure 7 below is taken from Table 4 of the latter report and indicates the decline in reclamation over a ten year period.

Figure 7: Mass of materials sold per sector (x 1,000 t pa)



Values

The reports quoted above suggest that the value of the reclaim sector (products) is in the order of £50 million, with an additional £13 million attributable to materials (see Table 7, right).



TOTAL REUSE (VALUE)	REMAN	PRODUCT RECLAIM	MATERIALS RECLAIM	MATERIAL SAVINGS (TONNES)	CO ₂ E (TONNES)
£63M	0	£50M	£13M	2,600,000	800,000

SCENARIO TO 2025 (CLIMATE CHANGE)	IMPACT
Retrofitting of existing buildings to lower carbon emissions – incentives to reward/offset costs	Greater amounts of waste arising from refurbishment and the provision of replacement products/materials. Unless aligned to low carbon ... this will be considered an acceptable consequence of achieving reduced carbon emissions from the operational phase of buildings.
Increased demolition of buildings, especially those not able/viable for energy efficiency upgrade	This is a likely consequence, especially in the drive to fit more homes on existing built land. Currently the bulk of C&D waste is related to demolition (though we don't know what the proportion is). Demolition rates are around 20,000 homes/year today. Estimates of four times this amount to meet the 60% carbon emission reduction have been suggested. This would significantly increase the amount of C&D waste from 100 MT/year to anything between 200 – 300 MT/year. Unless reprocessing facilities/markets are developed at a similar rate, resources will be lost/devalued and the percentage landfilled will increase. For example, opportunities need to be provided for planned re-use of demolition products at local plan level, such as use of masonry components for internal thermal mass in lightweight buildings.

Barriers

Barriers to increase of product reuse in this area can be briefly summarised as:

- **Prevalence of the notion of recycling as the dominant end-of-life option.** This is largely due to the success of WRAP in its waste segregation activities and the need for a site waste management plan.
- **Insufficient consideration of planned deconstruction during the development and approvals phase.** This is because demolition is a last minute activity, is seen as a cost-bearing element and requires more time and care than other options.
- **Concentration on energy in use rather than energy embodied in the materials.** However, as buildings become more energy efficient, this aspect will again rise in importance. In addition, metrics for the benefits of reuse are poorly known and are not widely stipulated or reported as benefits for projects in either the private or public sector.
- **There is a lack of credible, publicly acceptable retail-friendly formats** for the identification of reclaim opportunities, planned deconstruction, testing, screening, warehousing and presentation to the purchasing public.

Opportunities

Given the attrition on reuse generated by the push for recycling, it is clear that an opportunity exists to at least reinstate this fraction. Furthermore, the BRE/AEAT report¹⁴ in its summary of assumed policy drivers (page 4) identified two major factors likely to increase the volumes of material entering the waste stream and which might benefit from an improved reuse policy. These are described in Table 8.

In short, the requirements of the Government's carbon reduction commitments, the practicalities of the ever-tightening code for sustainable homes (and public buildings) and the requirements for climate adaptation will drive building upgrade and replacement.

This will manifest itself as a need to improve building performance whilst reducing total impact of construction materials. Reuse undoubtedly forms a component of this since, as building energy efficiency increases, the relative impact of the build phase becomes higher. The BRE/AEAT project that compared today's house to a 'zero home' found that the impact of materials would rise from 10% to 50% CO₂e emissions.

Even taking into account only today's best practices, Table 9 of the report identified that there were £450 million per annum worth

of opportunities to be achieved through clever (value-maximising) reclamation (yielding an increase of 15 million tonnes from the current 3 million tonnes) and reduction of indiscriminate recycling.

Admittedly, not all of this would be in the realm of products as opposed to materials, but perhaps a third might be attributable to this class of products (equal to around 4 million tonnes of product or 1.2 million tonnes of CO₂e).

In the short term, we fully expect what has been a marginal or informal sector activity to become much more commercially focussed, verifiable, professional and legitimised. The efforts by Bioregional to establish a sound business basis for construction reuse – the so-called ‘ReY centres’ – modelled on the US experience, are much welcomed. Since support for their business concept development from CRR in 2007/08, they have achieved follow-on funding from WRAP and sponsorship by around five local authorities.

At the institutional level, it has been identified that the stalled Building Schools for the Future programme and similar initiatives aimed at upgrading the infrastructure could offer significant opportunities to normalise good de-construction practices. This will however, require the cooperation of local planning authorities in planning for the activity in advance, and seeing it as an opportunity to reclaim value rather than a cost to be minimised. Appropriate metrics linked to environmental impact will be crucial, but much could be learnt from LOCOG’s purchasing initiatives for the 2012 Games.

ICT Equipment - Desktop Computers, Laptops & Servers

This area can be divided into desktops and laptops, the ‘client’ facing aspect of ICT, and servers, encompassing server machines and ICT infrastructure such as network switches.

Remanufacturing in Context

There are three distinct markets serviced by OEMs, third party resellers and the charitable third sector. Figure 8 describes the relationship between these markets.

There is a large and well developed market for supplying second use servers. Service led models by OEMs and whole package solutions mean that the quality and frequency of upgrades and changes to company’s server configurations is greater than would be expected for desktop devices. This is particularly true of larger and fast-growing organisations. Replaced equipment from these types of organisations is removed and resold as part of a package.

The scalability and redundancy of server computing power means that older equipment is suitable for reuse in less demanding tasks (generally in smaller businesses).

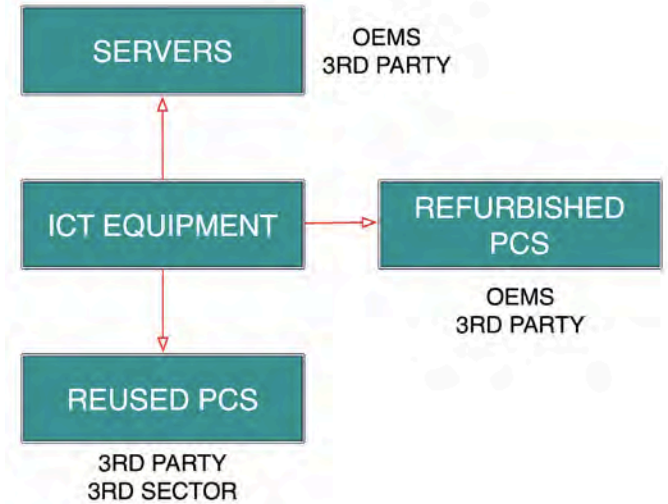
Refurbished PCs and laptops are generally end of line models, repaired warranty returns and customer returns/cancellations. Indeed, the majority of PCs and laptops sold as refurbished have never been used. There are dedicated OEM outlets as well as third party companies that specialise in selling these units. Separate divisions within the OEM have been established to specifically sell these units to the general public or third party resellers. The warranty supplied with the computers varies with operator but can range from equivalent to new (for example Dell outlet) through to very limited seven day warranties offered by smaller organisations selling on auction sites such as eBay. Prices for these systems are generally 10 to 15% lower than for the equivalent ‘new’ product.

There is a significant market selling old (over one year old) desktops and laptops. Access to old desktop and laptop PCs is usually precipitated either by individuals or organisations disposing of equipment with perceived performance deficiencies such as during upgrading programs and operating systems.

The hardware itself is usually functioning, but the average upgrade cycle for desktops is 3.5 years and 2.5 years for laptops. Due to the speed and lifecycle of the computer industry, the most up-to-date software and features are generally unsuitable for these products. The sale of these products is limited to non-premium markets where the latest functionality is generally not necessary. Within this category redeployment of suitable equipment is also a major activity. This is where IT equipment is cascaded through an organisation from more computer-power hungry applications to less demanding tasks.

There is a large number of both private and third sector

Figure 8. Relationship between reuse markets for ICT equipment



organisations operating in this area; they mainly service businesses who want to dispose of unwanted computer equipment. Anecdotal evidence suggests that the majority of private users will cascade their unwanted equipment through family, friends and private sales, with only the oldest (and therefore least suited for reuse) computers being sent for disposal. Charities engaged in this sector do so to supply ICT equipment to disadvantaged groups (either in the UK or in less developed countries).

Apart from ensuring appropriate environmental disposal of the product, most organisations recognise the need for complete removal of personal and confidential data from the computers and offer the appropriate services to guarantee data removal. Indeed, the safe destruction of data is one of the key services offered by asset management firms to corporate clients. Internationally recognised standards for data security, such as ISO/IEC 27001:2005



offer a framework to ensure the safe destruction of data. Schemes such as Digital Pipeline offer further security.

This charity was established with Microsoft to supply unwanted ICT equipment to less developed countries. In addition to ensuring the safe removal of sensitive data, the scheme provides approved outlets for useable ICT equipment, which reduces the likelihood that the donated equipment will be illegally dumped.

Older cathode ray tube (CRT) monitors have little or no resale value in the UK; there is some opportunity to sell full desktop systems to overseas markets in Eastern Europe and Africa, but there are some concerns that the difficulties in shipping secondary equipment are masking illegal dumping of WEEE. The WEEE Advisory Board is developing standards to ensure that this practice is prevented. There are also issues due to the poor waste infrastructure with disposal of this secondary equipment once it reaches the end of its useful life.

Table 9. Breakdown of UK sales volume for desktop/laptop PCs

TYPE	UNITS SOLD (000)	REFURBISHED (000)	REUSED (000)
Desktops	2,750	49.5	764*
Home Users	917		
Business Users	1,833		
Laptops	8,250	148.5	382
Home Users	4,950		
Business Users	3,300		
Servers	3,678		183
Total	11,000	220	1,150

Source: ONS Product sales and trade, 2009
* this number is half the actual because it includes monitors and base units

Table 10. Breakdown of UK sales value of desktop/laptop PCs

TYPE	VALUE OF SALES (£000,000)	REFURBISHED (000)**	REUSED (000) *
Desktops	320	15,400	38,200
Home Users			
Business Users			
Laptops	2,762	59,400	19,100
Home Users			
Business Users			
Servers	1,203		60,150
Total	3,082	74,800	57,300

Source: ONS Product sales and trade, 2009
*estimated at £50 per reused unit for desktop and laptops
**Estimated 80% retail price of new equipment

Remanufacturing processes

At the component level, there is little difference between PCs and servers. Microchips, printed circuit boards, magnetic and optical storage devices, cases and power units are essentially the same for desktop PCs and rackmount servers, with only their configuration and cost making these two categories distinct. Therefore, evaluation of the remanufacturability of the technology is identical for both sets of ICT. There are few moving parts within the machines meaning that fundamental re-working of the components is not possible. Parts which function correctly are left in place whereas inoperable components are replaced, either with new or with those cannibalised from other older stock. Units are then portable appliance test (PAT) tested to ensure electrical safety. Refurbished units are usually tested to ensure they work and then resold in their original packaging and supplied software.

Obtaining appropriate software licenses for reused computers (mainly for operating systems) poses a serious challenge for organisations. Some organisations have begun installing open source software such as Linux to minimise this problem.

ICT equipment should be considered as reused/repaired rather than remanufactured. This, though, should not detract from the industry: the premium refurbished units can be considered as virtually new; the majority of components included in the units which have been discarded for reuse at the end of their first life (after approximately 3.5 years) are unlikely to fail over a second lifetime. Components such as magnetic disks and fans can be easily and relatively cheaply replaced if necessary to ensure that a computer will perform as required over the requisite timeframe of its second life.

Values

11% of PCs sold in the UK are refurbished or reused.

It is difficult to determine an accurate number of refurbished

computer items sold yearly. However, a 2% return rate on all IT equipment would suggest that approximately 220,000 laptops and desktops are returned. These items are new or nearly new and therefore of significant value, the majority of these will therefore be suitable for refurbishing and resale, suggesting (assuming a 90% resale level) approximately 200,000 units will be sold as refurbished items in the UK.

In 2008, the average cost of a laptop in the United States was \$700 (approximately £450) whereas the average desktop was \$550 (approximately £350). Anecdotally these prices appear to be slightly low for the UK market, however, assuming that refurbished units are sold at 80% of their market value, this equates to a total refurbished computer market value of £74 million.

Data on reused computers were collected from several large reusers. Overall, an estimated 1,150,000 desktop and laptop PCs are reused in the UK. Due to the nature of this market, it is difficult to determine the end market for these computers and it is likely that a significant proportion will be sold overseas. Due to the age of these units, the resale value is likely to be low: anecdotally, these computers are sold on average for approximately £50 each, suggesting that the reuse market is worth £57 million.

Due to the lack of industry data, accurate figures over the value of this industry are difficult to find. However, the majority of the equipment is likely to be reused rather than refurbished (due to the nature of the industry), therefore, based on conservative estimate of 10% reused equipment at 50% market value, the value of this market is £60.15 million.

Trends

ICT equipment is in a constant state of flux. New hardware and software mean that five year old equipment is out of date. Overall sales of desktop and laptop PCs have dropped in the last year; two main reasons for which are the recession and the release of *Windows 7*. There is a continuing trend away from desktop computers in both the home and office environments. This will

Table 11. Market value - ICT equipment sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES)	CO ₂ E (TONNES)
192.45	0	75	117.45	11,531	20,064

limit the repair of broken units, reducing the overall amount of reuse performed.

The relatively small size and low price tag of netbook computers may further reduce the attractiveness of reselling older units, largely confining the market to charitable donations and export to secondary markets.

The drive for energy efficiency within large data centres may result in further supply of reusable equipment. There are concerns that energy savings through the purchase of new equipment may outweigh the benefits of buying reused.

Opportunities

Approximately 11 million desktops and laptops were shipped in the UK in 2008. Several reusers of old computer equipment claim to be able to resell approximately 70% of the material that is recovered. The largest source of this computer equipment is from larger business users, which account for approximately 50% of all sales in the UK. Assuming that all business users dispose of their equipment after three years, and 70% is suitable for reuse, there is a potential market of 3.85 million units per year.

Conversations with reusers of computer equipment suggest that the current market for desktop and laptop PCs is between 500,000 and 1 million units per year, suggesting that there is potential of growth within this area.

Industrial Tooling

Industrial tooling, including machine tools and cutting tools, is core machinery for almost all manufacturing industries. This equipment is used to work and shape metal or other materials into the correct form before it is assembled into a product. Due to the array of different tasks performed by these machines their size and operation varies greatly.

The function of industrial tools necessitates that they are well built and precisely constructed pieces of equipment. Their purchase represents a significant but necessary investment for manufacturers, with costs ranging from a few thousand pounds to

hundreds of thousands of pounds. This equipment is often central to manufacturing processes and required to produce thousands or millions of parts to within very fine tolerances, and may operate continuously until repair or maintenance is required.

Within the UK only a small number of industrial tooling OEMs operate. Some of these are large international OEMs with a site in the UK, others are smaller and solely UK based. The scale of this manufacturing industry was found to be in decline as cheaper equipment has become available from elsewhere in the world. However, tooling manufactured in the UK was perceived to be amongst the highest quality, with over 50% of UK production exported for use elsewhere in the world.

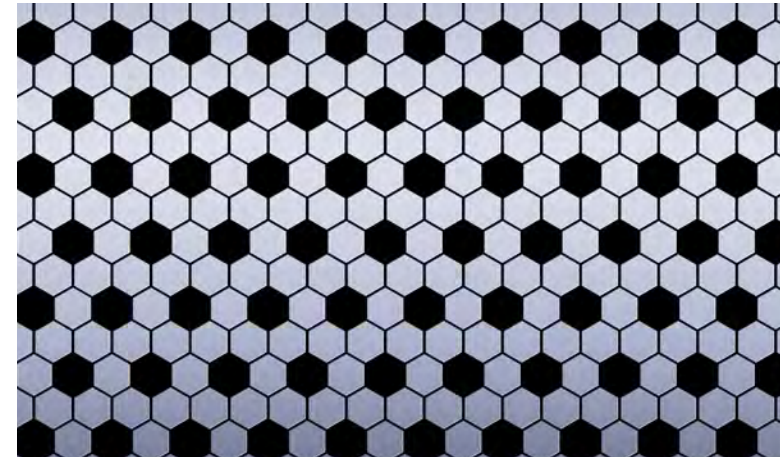
Despite the heavy use which many of these machines are subjected to, industrial tooling has a lifetime of many years due to its high build quality, value and core function within manufacture.

Maintenance, repair and servicing are relatively common for industrial tooling as this machinery is often essential to the operation of a manufacturing process.

End-of-life high quality machines retain residual value, and there is an active market in used machinery in the UK. These reuse activities occur as simple brokerage or site to site sales through to full remanufacture and upgrade. Lower value and quality equipment has a lower residual value, and will typically be scrapped rather than achieving a higher value end-of-life scenario.

Remanufacturing in Context

Within the UK, remanufacturing and reuse of these machines is relatively common, and the process of remanufacturing is well understood within the industry. However, there appears to be little consistency in how the terminology has been used, with 'remanufacturing', 're-engineering' and 'refurbishing' used interchangeably to refer to various practices. Within this sector different reuse options exists for industrial tooling depending



on their type. Cutting tools are relatively small and simple, most commonly consisting of a single piece of metal with a cutting edge. Regrinding is the most common renewal option, as this cutting edge suffers the most wear and tear and degrades most quickly. The simplicity of these parts means that full remanufacturing is not applicable, but other refurbishment occurs on a relatively large scale.

By comparison, machine tools are more complex and are of higher value; therefore remanufacture of this equipment is more common. Components or whole machines may undergo remanufacturing as part of servicing or resale activities. Modernisation is also common for these machines after 10 to 15 years.

In this process the core function of a machine is retained and regenerated. However, improvements to speed, flexibility and reliability are made. For example, CNC (computer numerical control), which is standard for all new machine tools, is commonly retrofitted to older equipment as part of a remanufacturing process.

Such processes can extend the lifetime of a machine tool by 10 - 20 years, and may be far cheaper than the purchase of a new unit. This level of remanufacturing or modernisation is only possible due to the original build quality of the machine tool.

Large OEMs were found to be uninvolved in the reuse aspects of this industry, having only service and maintenance operations. Smaller, more localised OEMs are far more active and often offer

Table 12. Value of industrial tooling recovery sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
70	25	25	20	4,667	8,260

remanufactured lines of their own equipment and parts. Third parties are also heavily involved in the reconditioned, refurbished and remanufactured tooling market, undertaking a large range of activities to meet market needs.

Trends

Our survey revealed that the scale of remanufacturing in this sector had been declining for some time. There was also a clear feeling within the industry that this trend would continue into the future, though some were optimistic that business would grow once the economy was more stable.

Values

Information gathered from industry indicated that the total market for reused industrial tooling was £70 million. The majority of the higher value remanufacturing was attributable to the remanufacture of machine tools, with lower value refurbishment and other reuse more applicable to cutting tool renewal.

Barriers

Two major barriers to remanufacture and reuse were observed in this sector; these have led to the recent decline seen:

- **Declining manufacturing base** - The gradual decline of the manufacturing industries in the UK has led to a lowering demand for machinery of this nature.
- **Low cost imports** – A large quantity of this equipment is now imported from abroad, presenting a cheaper, but often lower quality, alternative to purchasers. The lower costs of this machinery puts pressure on prices and remanufacturing becomes of marginal economic benefit. In addition, these lower quality tools increase the difficulty for remanufacturers in finding good quality core.



Opportunities

Remanufacture and reuse are already commonplace in this sector, and despite the current decline within this sector several opportunities exist. The benefits of remanufacturing and similar activities could be more widely promoted to purchasers. In addition to the costs savings, raising the awareness of advantages such as reduction of environmental impact or shorter lead times of remanufactured products compared to new could help develop new business.

Currently very little or no remanufacture and reuse activity stems from large OEMs. Examples of the business advantages of reuse and remanufacture may provide an incentive for instigation of these practices.

Consistent use of terms linked to renewal activities would provide more purchasers with greater confidence when seeking reused equipment. This could be achieved by adoption of the current remanufacture standard, or by industry specific guidelines.

A considerable proportion of remanufactured machines is exported; these are typically very high value machine tools. Expanding this activity to other tools may provide an opportunity for remanufacturers to strengthen their businesses. However, care should be taken as this may not be sustainable in the long term.

Ink and Toner Cartridges

Two printer technologies dominate the marketplace: Inkjet and laser. Although they perform the same role, the core technologies are different, and this is reflected in the varying remanufacturing techniques used on these devices.

Laser printers use electrostatic attraction to draw ink powder onto the sheet of paper which is then fused with heat. Inkjet printers spray wet ink onto the paper surface. Laser printers operate predominantly in a business environment, whereas inkjet printers are largely used in homes. Laser toner cartridges contain over one hundred moving parts and can weigh up to one kilo. Although colour is becoming more popular, black and white printing still dominates this market. Inkjet cartridges are much smaller, have few (generally no) moving parts and are almost exclusively colour.

Remanufacturing in Context

The remanufacturing industry relies on high prices of new OEM cartridges to offer the consumer a lower priced alternative. As most remanufactured cartridges are either sold under a trade name such as 'Ink Again' or as retailers own-label products such as PCWorld's PCLine brand, the public do not perceive remanufactured inkjet cartridges as 'remanufactured'. A variety of methods has been developed to obtain core. Particularly for inkjet cartridges, which are predominantly sold to consumers, gaining access to the core is difficult. Associations with volunteer and charitable organisations are widely used to obtain material. Remanufacturers pay for the core collected by these groups.

These collaborations benefit the remanufacturer by increasing supply of core; people are more likely to donate their used print cartridges to charities, and office-workers are more willing to spend time collecting the cartridges and packaging them up if it is for a 'good cause' rather than for another business. Larger scale remanufacturers use return envelopes, where possible supplied with a full cartridge.

Inkjet

Inkjet cartridges can be subdivided into two separate technologies: separate printhead and ink reservoir, and a unified printhead and reservoir. In general, the former design is favoured by Canon and Epson. The printhead assembly is made of two distinct components: the printhead and an ink reservoir.

The printhead is a permanent component in the printer: it contains the majority of the electronics involved with the printing process and the high precision nozzles that inject ink onto paper. The ink reservoir is essentially a small plastic vessel containing ink. Only the ink reservoir is replaced to refill the printer with ink. The ink reservoirs are generally low in value, with only small amounts of electronics and are relatively easy to produce. In general, due to the low value of these products and relatively low price of OEM replacements, these cartridges are not remanufactured in the UK. However, there is significant competition from third-party 'compatible' cartridges. Several cases have been brought against manufacturers and distributors of these cartridges because of breaches in copyright.

Unified cartridges contain both an ink reservoir and a high precision printhead. The fully integrated nature of these cartridges makes them more complex and, as such, they have a higher inherent value than the separate cartridges. This is where the majority of remanufacturing effort is focused within the inkjet sector. Heavy investment by remanufacturers has turned a relatively crude activity into an automated industrial process. Purpose-built machines for refilling and cleaning inkjet cartridges are available. Larger remanufacturers also custom-build refilling machines to cope with a large throughput of cartridges.

Toner cartridge

Toner cartridges are considerably more valuable per item than inkjet cartridges. Their design incorporates an ink store and a large print head (generally made of aluminium) which is the same width as the paper. The toner cartridge can contain more than 100 moving parts. Varying levels of ‘remanufacture’ are performed on these units from dubious practices where toner is refilled and then shipped with little additional process to the cartridge, through to full disassembly, part replacement, reassembly and testing.

Clearly there is a significant difference in the quality and reliability of these units. The complexity of these units makes automation difficult; this results in manually intensive remanufacture.

Aggressive pricing by the OEMs has led to a decrease in

remanufacturing in the UK; suppliers are now collecting toners for export to the Far East. These are being remanufactured and re-imported into the UK. Because of their weight and because the main customers for these cartridges are businesses (and therefore fewer in number than consumers) remanufacturers offer specialist collection services, generally by collection in bulk. These types of service enable remanufacturers to access end users and supply their product whilst collecting for further remanufacture.

Values

There are approximately 400 remanufacturers in the UK, employing around 2,000 people. Virtually all remanufacture inkjet cartridges and 50% of them toner cartridges.

Trends

The techniques for remanufacturing toner cartridges is now at a stage where there are training courses for remanufacturers and an industry devoted to providing parts. There are specialist refilling machines for remanufacturing inkjet cartridges.

There are some attempts by the OEMs to reduce the quantity of material that is being used in cartridges. Kyocera Mita use a unique technique where the printhead mechanics are a permanent fixture of the printer and the toner cartridge is a simple vessel, containing



very few moving parts and made of only one type of plastic. This system allows simple recycling of the empty cartridge and with the added benefit of lower embodied energy in manufacture.

There has been a general move away from integrated printheads on more expensive inkjet printers as the consumer begins to recognise the overall cost of ownership and price per printed page. Clearly this will have an impact on the size of the market available for remanufacturers.

Barriers

End user perceptions of ‘remanufactured’ inkjet cartridges are quite difficult to judge. Artificial testing has been carried out by various consumer bodies and international laboratories. Test results on the quality of the prints of remanufactured cartridges compared to ‘new’ OEM ones are not conclusive. This suggests that if good quality remanufactured cartridges are chosen, differences from ‘new’ are small, and that personal preference will dictate which cartridge a consumer buys.

This ever-changing technology has had its impact on the remanufacturing industry. Early attempts involved simply refilling the cartridges using syringes and bottles of ink supplied to the consumer. Generally these attempts to refill the cartridges produced poor print quality and ink spillages. These early attempts undoubtedly damaged the image of the industry.

Remanufacturers source parts and ink through large multinational companies. This sector of the industry is highly sensitive and has,

Table 13. Sales of UK inkjet cartridges

CARTRIDGE TYPE	SALES (MILLION CARTRIDGES) (% OF TOTAL)				WEIGHT (G)
	TOTAL	OEM	REMAN	COMPATIBLE	
Mono laser	28	21.7 (77)	6 (21.1)	0.49 (1.7)	300-1,000
Inkjet	70	53 (75)	11 (16)	6 (9)	21-100
Total	98	74.7 (76)	17 (17)	6.49 (7)	

Table 14. Value of UK inkjet cartridges sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES PLASTIC EQUIV)	CO ₂ E (TONNES)
435	435	0	0	2,485	6,287

The base figures are those supplied by Recycler magazine and Lyra research. The weights of average inkjet printer and laser printer cartridges are 35g and 350g respectively. The cartridges are made of 100% plastic. The costs of remanufactured inkjet and toner cartridges are £15 and £45 respectively. Both inkjet and laser printers contain smart chips which are composed of silicon copper and other non-ferrous metals. Toner cartridges also have metal components.

on several occasions, fought legal battles over the production of these compatible parts. Obtaining high quality core is one of the central problems to the industry. As described above, reverse logistic techniques have been developed to ensure quality of supply.

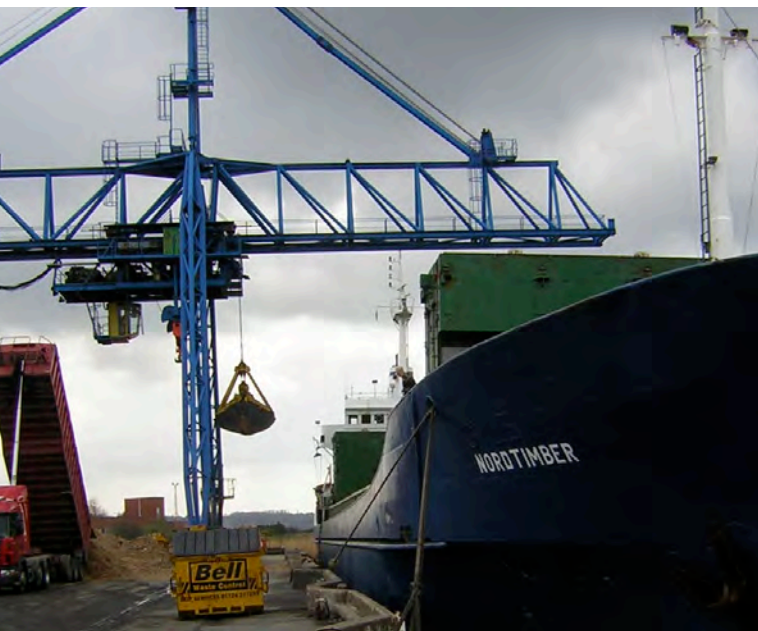
Opportunities

The majority of inkjet core is landfilled. Therefore there is a large scope to increase the number of good quality core available for remanufacture. The remanufacturers claim that their failure rates are usually lower than the corresponding OEM cartridges.

The lower returns rates are attributed to the fact that, unlike OEM cartridges, all the cartridges undergo print tests before they are boxed and shipped. Promoting this message will increase sales.

Lifting and Handling Equipment

Lifting and materials handling machinery covers a diversity of equipment used for a large variety of tasks. The total turnover for manufacturing of this equipment was £4 billion in 2007 with a gross value added of £1.5 billion; both these values have risen slightly over the previous five years. To simplify analysis, this sector has been broken up into three subsectors.



Cranes and Hoists

Cranes and hoists form the largest group of machinery in this sector. This equipment is most commonly used in the construction, manufacturing and transport industries. Examples of this type of machinery include: 'cherry pickers' used for access to elevated work sites; 'hoist type cranes' used for the movement of stock in warehouses and 'mobile and construction' cranes used for large scale building projects.

Worldwide there are a few, well established OEMs of this machinery which dominate the sales markets, particularly for larger cranes. As well as these large organisations a group of smaller manufacturers also operates, typically producing smaller or more specialist equipment.

OEMs supply two types of purchaser. Some machinery is bought directly by end-users; this is more typical of static or small equipment, or where long term use is required. However, the nature of this equipment means it is commonly required for specialist purposes, or to meet a short term need. Therefore, a large industry exists around leasing equipment from specialist hire companies which in turn are the direct customers of the OEMs.

Forklift Trucks and Other Industrial Handling Equipment

Forklift trucks and other industrial handling equipment are used to manoeuvre heavy items, typically in warehouses or other areas of industrial activity. Various sizes and types have been developed to meet a diversity of needs, for example ranging from handling small pallets to ship containers.

The most accurate sales estimate from within the industry was that 30,000 forklift trucks are sold annually in the UK, with an average price of £15,000; this corresponds to a total market value of almost £450 million.

There are a number of OEMs operating in the UK; however these are mainly sales based activities with manufacture occurring abroad. Forklift trucks are relatively affordable so companies will purchase them outright, though some OEMs also offer leasing and servicing options. Independent leasing companies also exist for short term

forklift truck use; these companies often offer maintenance and repair services. Many of these leasing companies offer pre-owned forklift trucks, which may or may not be refurbished.

Lifts and Escalators

The Lift and Escalator Industry Association estimates that they cover 250,000 lifts and escalators. The industry consists of four or five major OEMs, and a long tail of smaller companies operating varying levels of service type activity.

Remanufacturing in Context

Cranes and Hoists

The structure and composition of cranes and hoists would seem to lend themselves well to remanufacturing activities. This equipment is typically of high value, produced from well made components and has a relatively modular design. However, the level of remanufacturing is relatively limited in this sub-sector as a consequence of a number of barriers, and as such the term is poorly understood. Refurbishment is more prevalent throughout the industry, and is commonly referred to as such. At present, some OEM remanufacture does occur, however this is happening on a limited scale and not in the UK.

This is partly due to the way in which the market operates and partly due to the costs associated with manufacturing new cranes and parts abroad. Some more localised informal remanufacture occurs, particularly of specialist equipment (as this equipment is difficult or expensive to replace). This work is typically performed by third parties, which are not necessarily crane specialists, but have good engineering backgrounds.

There is also a small amount of remanufacturing of older cranes which have a highly specific function, and remanufacturing is cheaper than the provision of the specialist new crane.

Servicing type activities are more common in this sector as owners maintain this equipment to a high level to keep it functioning and to meet safety standards. This maintenance ranges from simple tasks such as cleaning and painting to the replacement of

major components such as bearings and electric motors, some of which are reclaimed for reuse. Less frequently, structural work is undertaken to repair or strengthen welding. However, once this maintenance work is no longer economic, this machinery is either scrapped or sold on to territories with lower safety requirements.

Forklift Trucks and Other Industrial Handling Equipment

Reuse and remanufacture occurs at a moderate level; some OEMs undertake full remanufacturing on a minority of their trucks – these processes are consistent with the definitions described elsewhere. A representative from one major OEM stated that they remanufactured forklift trucks, though on a small scale.

It was estimated that around 200 trucks a year were sent from the UK to a remanufacturing facility abroad, and approximately 150 trucks are returned to the UK in this scheme. These remanufactured trucks are priced at approximately two-thirds the cost of new, and have a 12 month warranty. These units are put on the market to compete with cheaper trucks originating from Asia, rather than offering an alternative to the OEM’s own higher value trucks.

A moderate amount of lower quality refurbishment also occurs, normally by third parties; again this appears consistent with the formal definitions in this area.

The independent third party work that is carried out has shifted from remanufacture orientated activities towards refurbishment due to the costs involved. This refurbished market is localised and fractured, characterised by a plethora of small independent companies. Refurbishment usually involves repainting, repair

and a few service checks; therefore it is broadly consistent with refurbishment in other industries.

Lifts and Escalators

Both lifts and escalators are installed as part of a building’s construction, and therefore are difficult and disruptive to replace. They are generally of bespoke designs as each location will be different due to varying building designs. Remanufacture and reuse in the lifts and escalators industry is very uncommon.

On rare occasions a motor will be rewound in situ if it is impossible to replace it. It is also not practical to remove a lift or escalator from one site and transfer it to another due to the unique nature of each unit. Therefore, remanufacturing has little recognition in this sector. However, the core mechanisms of this machinery are well constructed, and with a high level of maintenance and overhaul they will last 25 years or more. Throughout its lifetime component parts like bearings will be replaced, motors serviced and upgrades to systems made where necessary – particularly the installation of new safety features.

Major repair to lifts and escalators is difficult, and removal of old parts and installation of new can be achieved more quickly than waiting for a repair. If key parts require a major overhaul they will normally be scrapped and replaced by new.

This approach minimises the disruption caused by a non-functioning lift or escalator. Other, non-mechanical parts will also undergo overhaul; however, improvements will be focused on aesthetics or modernisation rather than remanufacture or refurbishment.



Trends

Cranes and Hoists

It is unlikely that the level of full remanufacture in this sector will increase in the near future, and equally the demand for remanufactured cranes and parts is unlikely to change. Safety regulations are currently becoming tighter, making remanufacturing more difficult. The level of technology incorporated into this equipment is increasing and, as with other industries, as more electronics are brought in remanufacturers will struggle to keep pace.

Forklift Trucks and Other Industrial Handling Equipment

As described above there is some OEM engagement in this sector, for example Jung Heinrich’s German remanufacturing facility. Only a small proportion of trucks go through these schemes, and volumes have the potential to be increased.

However, it was indicated that setting up and growing such a scheme is expensive and problematic, thus there needed to be a

Table 15. Value of UK cranes and hoists sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
18	3	7.5	7.5	1,200	2,124

Table 16. Value of forklift trucks and other industrial handling equipment sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES)	CO ₂ E (TONNES)
20	5	10	5	1,333	2,360

Table 17. Value of UK lifts and escalators sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
15	---	15	---	1,000	1,770

strong business case for doing so. Therefore it seems unlikely that this sector will see dramatic growth in the short term. Independent activity has been declining steadily, as it seems likely that the decline will continue as newer trucks become more complicated, and imports become cheaper. Various independent companies stated that they undertook full remanufacturing work up until the last 5-10 years.

Remanufacturing activity has gradually declined as the cost of labour makes it less economic, and now solely refurbishment occurs. This decline appears likely to continue into the near future.

Lifts and Escalators

This industry is unlikely to change; in order to incorporate remanufacturing a step change in manufacturing practices and attitudes is required. Therefore the low value associated with remanufacturing and reuse in this sector is unlikely to change.

Values

Cranes and Hoists

Full remanufacturing in the cranes and hoists industry is relatively uncommon, and these activities are worth around £3 million in the UK (see Table 15, previous page). However, excluding 'routine maintenance', the ongoing refurbishment work, component replacement and reuse side of the industry has a higher value.

Forklift Trucks and Other Industrial Handling Equipment

Reuse and remanufacture occurs at a moderate level; some OEMs undertake full remanufacturing on a minority of their trucks, but there is a reasonable amount of refurbishment and other reuse occurring. See Table 16, previous page.

Lifts and Escalators

It is apparent there is very little remanufacture occurring within this sector, and we assess this to be of insignificant value. However, there is a variety of activities associated with refurbishment and reconditioning of lifts and lift mechanisms. We estimate this to be worth £15 million (omitting modernisation and repair type work).

Barriers

Cranes and Hoists

- **Safety concerns** – Safety is of prime importance in this industry, and a large number of regulations apply. Within the UK these are stricter than elsewhere, partially due to some high profile accidents in recent years. This attitude influences purchasers, who are less likely to buy used equipment, remanufactured or otherwise, than in many other industries. Difficulties in obtaining documents outlining the origin, usage and maintenance of equipment further contributes to this, as issues such as metal fatigue will not be revealed by a simple inspection. Detailed records would provide purchasers with greater confidence in used cranes; however, this would also incur an additional cost.
- **Costs** - It was indicated that the costs associated with remanufacture limit its penetration. These costs are partially linked to safety aspects, as additional work is required to meet the formal (and informal) safety policies.
- **Technology** – Technological advances have also made remanufacturing more difficult, as cranes incorporate increasing amounts of electronics. This lowers the appeal of remanufacturing as electronics require a further set of skills and knowledge, often outside the traditional skills of people working in this industry.

Forklift Trucks and Other Industrial Handling Equipment

- **Costs** - The largest barrier to remanufacturing in this sector is the decreasing cost of new trucks. These lowering prices have squeezed both OEM and third party remanufacturers operating in this area. As with other industries, customers favour a cheap new product over a similarly priced remanufactured equivalent.
- **Technology** – New technology has also hindered remanufacturers, particularly third party operators. The increasing amount of electronics in fork lift trucks adds complexity and cost to the remanufacturing process. The increase in use of these parts also means that remanufacturers require a different set of skills to those traditionally required for this activity, putting additional pressure on them.

Lifts and Escalators

- **Machinery** - Probably the largest barrier to remanufacture and reuse in this sector is the nature of the machinery. In general, systems are not alike, therefore to incorporate remanufacturing either a vast array of parts needs to be kept in supply, or the unit kept out of use while the part is remanufactured. Neither option is ideal, therefore new parts are most commonly used.
- **Attitudes** - A secondary barrier to remanufacture and reuse is the attitudes within the industry. Lift and escalator operators prefer to avoid unnecessary downtime, and the use of remanufactured items does not fit in with this desire due to preconceived ideas about lower quality parts. Concerns about possible safety implications also come into consideration as parts of the industry are heavily regulated.

Opportunities

Cranes and Hoists

This is an area of low remanufacturing activity, and this is unlikely to change in the near future. However, there are several enablers which would help to increase the extent of remanufacture:

- **Improved awareness of OEMs' remanufacturing activities** – Raising the profile of this option, as well as the benefits will make it more likely to be considered as an option in the UK.
- **Better legislation covering safety aspects** – Includes possible reuse and remanufacture options. This will improve purchasers' confidence in these products.
- **Better understanding of how usage affects crane integrity** – Recording usage data and better interpretation would provide a much greater incentive for the reuse and remanufacture of cranes.

Forklift Trucks and Other Industrial Handling Equipment

Some OEM remanufacture already occurs in this sector; there is potential for this to be expanded if a market can be developed for remanufacturing fork lift trucks. This could be achieved by

increasing customer awareness of the benefits of remanufacturing; this would help develop a larger market, and increase the quantity of core returned at the same time.

At the time of writing full third party remanufacture is simply not economic under normal situations, and this is unlikely to change in the near future unless the cost of labour reduces or the price of new trucks increases. Potential remanufacturers would need to distinguish their products from others, either through their quality or possibly by adopting more service based business models.

Lifts and Escalators

In the short term it will be difficult to change the way in which this industry operates, and it is unlikely that reuse or remanufacturing will become an established practice within this sector. One possible intervention is for manufacturers to further standardise parts, particularly for escalators. This would encourage companies to keep an inventory of used and remanufactured parts. Elsewhere, remanufacture of gearboxes has been developed; however their use in lifts is becoming less common.

Medical, Precision and Optical Equipment

The medical, precision and optical equipment sector encompasses a diverse range of equipment and markets, therefore precision and optical equipment and medical equipment are described separately below. ONS statistics state that this sector has a turnover of £13 billion in the UK, with a gross value added of almost £6 billion.

Medical Equipment and Devices

Medical equipment and devices are central to the operation of modern healthcare and veterinary services. A wide variety of equipment is required by these sectors to provide the expected level of care, particularly in developed countries. In order to be accepted, this equipment must be highly reliable and present minimal risk to the patient and users.

By far the largest market in terms of value of equipment in the UK is the NHS.

Much of the equipment within this category can be considered consumable, particularly small single-use items such as syringes and tongue depressors. Other equipment ranges from uncomplicated, low value devices which perform a simple function up to much larger complicated equipment. This second type of equipment is of most relevance to remanufacture and reuse due to its higher complexity and inherent value.

Complicated equipment is manufactured by a specialist OEM or a division of a large OEM. Products manufactured by these companies are considered to be of high quality, reliable and safe; attributes which are clearly of importance in this sector. Due to the scale and demands of the industry there appears to be little room for smaller manufacturers, though some do exist supplying parts to the larger organisations or operating within niche markets.

Precision and Optical Devices

The equipment defined within this sector is varied; it is often used for quite specialist tasks and may be mechanical or electrical in nature. Examples include analytical equipment, utilities meters, metrology equipment, radars, telescopes and cinematic equipment.

This diversity of equipment results in some larger markets, such as domestic metering equipment, but also many different smaller niche areas. In general, this equipment is well made and of good quality resulting in a long usable life. Servicing plays an important role within this sector, and maintenance can often keep a piece of equipment functioning for as long as it is needed. Typically equipment will be used until it becomes obsolete, either because of technological advancements or due to functional redundancy.

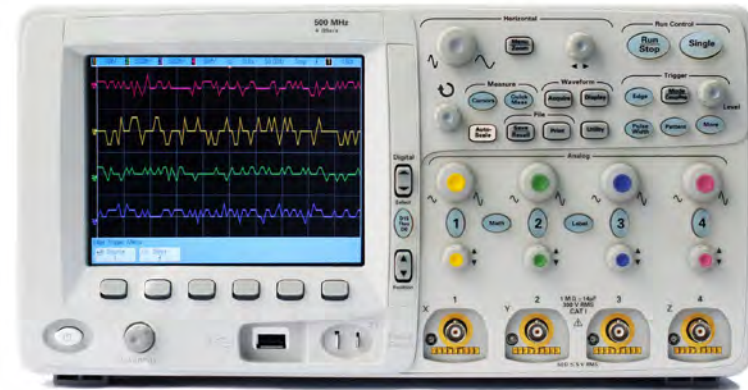
Once it reaches this end of use point most equipment has little or no value, and in many cases users will pay for its removal due to

Table 18. Value of UK medical equipment and devices recovery sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
24	4	10	10	849	1,503

Table 19. Value of UK precision and optical devices recovery sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
45	15	20	10	1,593	2,819



complicated waste disposal requirements. Certain equipment may retain use - and therefore value - at end of first use, and may be sold on. As is the case in other sectors, this principally occurs with higher value or difficult to source specialist items.

Remanufacturing in Context

Medical Equipment and Devices

The survey found that remanufacture, reuse and other activities are not common within the UK’s healthcare sector; as a result these terms were poorly understood. This is in contrast to many other countries where reuse, remanufacture and refurbishment are common and therefore familiar. Indeed, the EU’s Medical Devices Directive (MDD), which covers the UK, contains a specific set of regulations referring to remanufactured and refurbished medical equipment.

The MDD defines ‘refurbished’ devices as equipment which has been cleaned, repaired and returned to its original state. ‘Remanufacture’ includes this cleaning and repair aspect, but additionally requires the improvement of the function of the device. Whilst these terms broadly fit with the definitions discussed elsewhere, they can be considered more stringent due

the improvement required in the remanufacture of a device. However, it should be noted that usage does vary within other countries, therefore the standard definition of remanufacturing is used here.

Globally, the largest market for remanufactured and reused equipment is the USA. This is driven by the (currently) privatised healthcare system, which due to its nature seeks to drive down the costs associated with medical treatment. The scale of this industry is highlighted by a single company asserting that it saved the US healthcare sector \$138 million and over 2,000 tons of material from landfill in 2008 by supplying remanufactured and reused goods. This company performed third party remanufacture on goods ranging from complex equipment to some smaller, lower value electronic items.

OEMs also offer remanufacturing and refurbishment products; this appears to be limited to large, expensive pieces of equipment such as MRI and CT scanners, ultrasound and X-ray systems. Siemens, GE Healthcare and Philips and others offer pre-owned refurbished systems as part of their business with active sales in Germany, Australia, USA and elsewhere.

These systems are offered with a warranty and full service back up, which is necessary given the large capital expense of the equipment. The comparative lack of value in the UK can be attributed to the NHS, which dominates purchasing in this sector. However, some value was found in sales to the private industry. This was generally of high quality products, with some cascading of equipment to the lower value veterinary market also identified.

Precision and Optical Devices

The level of reuse of this equipment is relatively modest compared to the market size. This activity can occur through official OEM

channels, third parties and informal site to site sales. However, these sales appear to be around the edges of the market rather than being a fundamental element. 'Refurbished' is the term most commonly used in this sector, but may refer to a variety of different processes, and 'remanufacturing' has no specific meaning.

OEM activity appears to be focused on larger, higher value items of equipment, often occurring through service agreements, trade-ins or part exchanges. The cost of this new equipment is high, but it retains little residual value at end-of-life, and in certain cases disposal can incur a significant cost. One OEM, producing highly specialised and high value equipment, indicated that refurbished items were an important part of their business, and that the profit could be as good as - or better than - that from a new product. It was also noted that refurbishment activities may commonly overlap with what could be classed as remanufacturing.

A reuse market also exists for smaller equipment, with various levels of reconditioning, refurbishment and remanufacture occurring over the breadth of this sector. This element of the industry is characterised by smaller companies, typically with 5-10 employees working within a relatively specialised product area.

The nature of this equipment means that specialist skills and knowledge are normally required to remanufacture or repair equipment, particularly in the field of electronics. The equipment sold is typically 25 to 50% of the price of new, depending on its condition and age.

This price variation is indicative of the different degrees of reuse occurring, ranging from remanufacturing down to simple brokering. It was also noted that the highly specialised nature of equipment and the niche markets which exist in this sector mean that it was difficult for smaller businesses to grow, as expanding into new product ranges required new knowledge and skills.

Trends

Medical Equipment and Devices

At the current time very little remanufacture or reuse type activity occurs in this subsector when compared to the overall size of the

market. This appears to have been relatively constant since the earlier survey (though no value was assigned previously). Our research indicates that it is unlikely that any variation would be observed in the near future as few barriers will alter in the short term.

Precision and Optical Devices

Overall, there appears to be a moderate amount of remanufacture and reuse within this sector. Some OEMs offer refurbished products as part of their core business. However, much of the third party activity is based around businesses seeking cheaper but lower quality equipment, thus brokerage activities are also common.

There has recently been a general decline in the total market for equipment; this is also impacting refurbishers and remanufacturers. Some businesses contacted indicated that refurbishment was no longer part of their business as they did not believe the market was sustainable. It seems unlikely that much will change in this sector in the short term.

Values

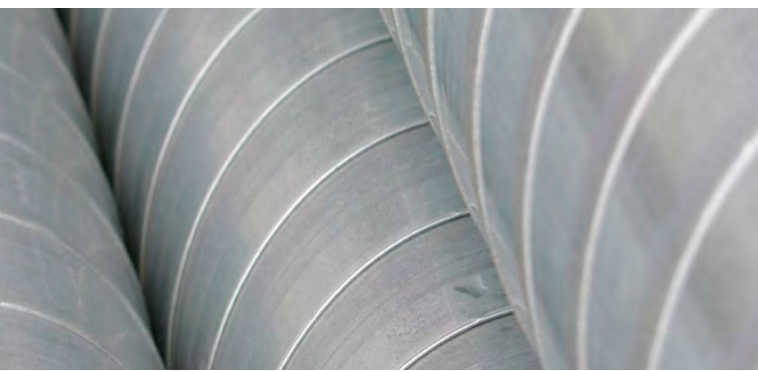
Medical Equipment and Devices

It is clear that medical devices make a small contribution to remanufacturing activities in the UK; we estimate the contribution to be around £5 million. However, this value is not reflective of the degree of remanufacturing occurring elsewhere in the world. The refurbished and other reused options are worth £20 million, roughly evenly split.

These figures give an indication of the value; however the quantity of equipment is lower due to the high values associated with this equipment.

Precision and Optical Devices

We estimate the total market for used equipment in this sector, including remanufacture, is £45 million. The majority of this equipment will have had a brief check to ensure it functions and possibly a cursory clean for aesthetic purposes.



A minority of equipment undergoes more intensive treatment, more aligned to remanufacturing practices. The value of this equipment is calculated to be £15 million.

Barriers

Medical Equipment and Devices

- **NHS purchasing** – The primary barrier to remanufacturing in the UK was identified to be the purchasing strategies of the NHS, which prevent both OEMs and third parties operating remanufacturing and reuse schemes in the UK. Very little, if any, reused equipment is bought by the NHS, and as this is the largest market for medical equipment in the UK it limits the extent to which reuse and remanufacturing can occur in this sector.
- **Costs** – The costs associated with remanufacturing equipment for use in this sector also make it a difficult area for businesses to operate in. As described above, a large number of regulations must be met for a remanufactured product to be sold into this market. While these rules are clearly necessary for the safe operation of this equipment they place an additional cost burden on remanufacturers. Further costs are incurred, for example the need to sterilise used equipment before it is processed to prevent workers being infected - inoculations may also be required.
- **Attitudes** – Purchasing attitudes also have a significant influence; many purchasers believe that remanufactured and reused products are of inferior quality, clearly an issue when associated with healthcare industries. This view is possibly reinforced by the lower quality refurbished equipment which is available to less restrictive markets such as the veterinary industry.
- **Technology** – The rapid rate of development of technology and equipment can also become a barrier, as manufacturers utilise much of their resources for developing new and improving on existing products. This rate of change places additional pressure on both equipment manufacturers and purchasers to

keep up with the latest technology. This development impacts on remanufacturers and refurbishers as they also need to keep up with the pace of developments and innovation in this sector in order to make their equipment attractive.

Precision and Optical Devices

- **Attitudes** - Customer perceptions strongly influence this sector. Many purchasers will prefer to buy new simply because they place more trust in it or want the best the market has to offer. This pushes down the price of reused equipment, therefore reduces the viability of remanufacturing and reuse due to the costs involved.
- **Technological development** - Technological advances of this equipment were stated to have an effect on remanufacturing and reuse. By the time equipment is no longer useful to an owner it is likely to be completely outdated and unable to meet baseline expectations. Often the most common reason for purchasing this equipment would be for infrequent use at a small start up business which is not an extensive market.

Opportunities

Medical Equipment and Devices

As described above, the purchasing of pre-owned equipment in the UK is at a comparatively low level compared with other countries. However, there is good evidence from elsewhere that remanufacturing and reuse in this area can successfully be expanded. The US system demonstrates that this market can be developed successfully, without lowering the quality of the equipment offered.

Further encouragement could be provided by raising awareness of the environmentally friendly and ethical aspect of reuse, as this fits with the overall ethos of the industry. Initially non-critical equipment could be focused on to allay some of the fears over patient safety; this would provide a basis for reuse and remanufacturing within the market. Altering purchasing policies within the NHS holds the largest opportunity in this sector, as it

would help create a sizeable market for reused equipment in the UK. This would generate new business opportunities for companies desiring to operate in this area.

Precision and Optical Devices

There is certainly an opportunity growth in remanufacturing and reuse in this sector if the correct purchasing attitudes are adopted and attractive products offered.

OEMs could expand their current refurbishment activities and promote these more clearly, particularly the environmental benefits. This would provide a better basis for these activities, and may encourage growth into new sectors.

Conversely, third parties are likely to continue to struggle and further converge towards brokerage activities rather than skilled remanufacture. However, there appear to be opportunities for remanufacturers of specialist niche equipment, where the size of the market may not be attractive for larger organisations to quickly develop and rapidly outdate equipment.

Off-Road Equipment

The equipment included in this sector includes motorised and unpowered machinery used within the agricultural, construction and mining industries.

The manufacturing of this equipment contributes close to £5 billion to the UK economy. However, a considerable quantity of new equipment is manufactured and assembled abroad before being imported to the UK. Therefore, the market for new machinery is likely to be larger than the headline figure of £5 billion.

The majority of machinery in this sector is produced by large final assemblers (FAs) which operate globally, and typically specialise in a particular type of equipment. Some FAs also undertake component manufacture in-house, however many parts are manufactured by specialist contracted OEMs. Once assembled, this machinery is sold to end-users or equipment leasing firms with a warranty and often a service agreement. To support these agreements FAs have large servicing divisions, and often integrate



are commonly remanufactured in all industries. Refurbishment and reconditioning also occurs, but this is more prevalent for other, less complex equipment.

Remanufacturing forms a core part of many FAs' business activities in this sector. Typically this is linked to providing parts for warranty replacements and servicing. As such, these operations are often transparent to the owners of the equipment.

The range and scale of remanufactured products is variable. Some of these companies offer a wide range of remanufactured parts and equipment, which is typical of the construction industry; others only offer specific items such as tractor gear boxes. The actual remanufacturing process is often performed by contracted OEMs or third parties rather than FAs, as these organisations have the specialist skills needed to remanufacture to a high standard.

By far the largest practitioner of remanufacturing in this sector is Caterpillar, which operates remanufacturing schemes globally. However, other FAs and OEMs, such as JCB and Komatsu, have sought to increase the level of parts remanufacturing as they recognise and promote the economic and environmental benefits. Many OEMs now offer a comprehensive selection of parts ranging from engines and gear boxes to hydraulics and pneumatics to starter motors and turbochargers – parallels can be drawn between this range of components and those remanufactured in the automotive industry.

Independent third parties also undertake various different renewal activities on this equipment. Remanufacturing on this scale appears to be limited to engines and gearboxes, probably due to historical factors.

Outside these areas there is little evidence for the existence of independent remanufacturers; third parties appear more aligned to repair work rather than true remanufacture. One exception was

the remanufacture of older equipment for export, which is most commonly carried out on engine powered vehicles. For example, there are several companies in the UK which remanufacture tractors primarily for export to Africa and developing countries elsewhere in the world.

This is viable as machinery undergoing this process is no longer desired in the UK market due to its age, and remanufacture is easier due to its older, uncomplicated less complex design. Some remanufacturing of smaller machinery was also identified, for example lawnmowers are commonly remanufactured by small, local operators, mostly supplying the domestic market. While this is not on the scale of the aforementioned, it highlights that remanufacturing can occur on a small scale within this industry.

Remanufacture was found to be far less common for non-motorised equipment. This equipment does not lend itself to remanufacture as it requires less effort to maintain in a working state and has fewer high value parts which are liable to wear. Despite the low incidence of remanufacture, other related activities occur quite extensively, particularly on an informal basis. For example 'revitalisation' of agricultural equipment - which may occur every five years or so, to bring a piece of equipment up-to-date, or repair which is commonplace throughout this sector.

In addition to these mainstream activities a large amount of work is unrecorded as it is undertaken on an informal basis by end-users. This activity ranges from repairing, to rebuilding, to modifying to suit specific needs. However, due its fragmented and localised nature, and the variation in type of work carried out, it is difficult to gauge accurately the scale of these activities.

Trends

The trends observed in this industry depend on the type of operator involved. In the case of FAs and OEMs there has been an increase in the scale of remanufacturing over the past few years. This has been driven by competition between companies within the sector, as they seek to lower the cost of their warranty and servicing operations.

The growth has been both in the volumes of remanufactured

purchasing and servicing into a single agreement – this is described in more detail below.

Despite the need for servicing and repairs, industry representatives indicated that, due to the nature of the work this equipment carries out, it is well built, well looked after and has a long lifespan. Older pieces of machinery are often kept and maintained to provide back-up to newer equipment, particularly in the agricultural sector. Most end-of-life equipment was generally seen to have little or no value, therefore once obsolete or beyond economic repair it will be treated as scrap or cannibalised locally for spare parts. A market for good quality pre-owned machinery exists; typically this is concentrated around brokerage and site to site sales. Little if any remanufacturing or refurbishment is undertaken as part of this.

Remanufacturing in Context

Remanufacturing in this sector is well understood, accepted and clearly distinguishable from refurbishment and other renewal type activities. There is a high level of remanufacturing activity, the vast majority of which occurs on engine powered machinery such as tractors and earth moving equipment. This machinery utilises engines, gear boxes and other drive train sections; parts which

Table 20. Values of UK off-road equipment recovery sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
380	165	25	190	25,333	44,840

parts, and number of parts offered. However, it was also noted that some companies in this area, particularly the agricultural and mining equipment manufacturers, are not engaged in these activities. These organisations either appear uninterested in remanufacturing or are simply unaware of the potential benefits.

The situation is different for third party operators. Pre-owned machinery and parts in this sector are now most commonly sold-as-seen, often through brokers. Several of these brokerage companies indicated that they had undertaken some level of remanufacture in the past. However, due to the cost of labour and the lower prices of new machinery this had declined over the last 10 years, and it had now become completely uneconomic. In the short term this seems unlikely to change, and remanufacturing will be limited the niche markets.

Values

We estimate the value of true remanufacturing in this sector is £165 million; this is predominantly attributable to FAs and contracted OEMs using remanufactured parts in their warranty repair schemes. Lower tier remanufacturers also operate in this industry; however this represents a broad range of activities from independent third parties to informal on-site repair and refurbishment. Measuring the full extent of this activity is impossible, however around £25 million can be attributed to higher quality refurbishment activities.

Other reuse options in this sector are difficult to quantify due to the informal nature of most of this activity, however we estimate that these are worth as much total remanufacturing and refurbishment value.

Barriers

- **Core management** - The largest barrier to increasing established large scale remanufacturing processes by FAs was obtaining sufficient core. These are typically acquired through warranty returns or as exchanges through their product support divisions. Discussions with these operators indicated that core management was central to their remanufacturing activities, for example surcharging of parts was often used to improve retrieval rates. In practice these measures were not always successful in

securing enough core for the scale of remanufacturing.

- **Initial capital outlay** - For large organisations not undertaking remanufacturing the largest barrier to instigating these operations was the initial cost of implementation. Significant investment is required to start up remanufacturing on a large enough scale for it to be worthwhile; this has prevented or slowed down the entry of some FAs into this market.
- **Costs** - Our survey indicated that remanufacturing activity by smaller, third party operators has been declining for some time, and at the time of writing it was no longer economic for them to remanufacture this equipment. The biggest influences on this are the increasing costs of labour, and the lowering prices of imported equipment which compete with remanufactured items.
- **Long lifetime** - The longevity of equipment may also have a detrimental impact in the context of remanufacturing. The machines are built to last and have a long life time. Typically once end-of-life is reached they are almost impossible to remanufacture to the specifications of equivalent new machinery. Therefore there is often little incentive to operate higher value remanufacturing practices.

Opportunities

The largest opportunity for growth in this sector is increasing the scale of FA and OEM remanufacturing. Many are already operating and growing large scale remanufacturing activities, demonstrating its viability. Increasing the awareness of the economic and environmental benefits of remanufacturing with larger organisations would help increase this.

In the past it has been demonstrated that third party remanufacture is viable, however this has now fallen away.

Actions could be taken to raise the level of third party activities from simple refurbishment. As with other sectors, increasing economic incentives would provide the greatest motivation.



Office Furniture

The furniture industry in the UK is considerable – the fourth largest manufacturing industry in the country – valued at around £10 billion¹⁵. Of this, the office furniture sub-sector accounts for approximately £680 million equating to a mass of between 165,000 and 200,000 tonnes.

Office furniture generally encompasses seating, desks and pedestals, steel or wooden storage units, and a small percentage (2.5% of sales) of miscellaneous items, including partitions¹⁶. The majority of this has a long service life of around 9 to 12 years, but is often replaced for reasons other than damage or other loss of function.

Industry operators suggest that it is common practice to replace an entire office suite rather than individual items unless severe damage has occurred to a particular piece. This is normally motivated by office moves or rebranding of corporate image, and frequently results in many fully functioning pieces being sent to landfill.

Table 21. Value of UK office furniture recovery sector

TOTAL REUSE VALUE (EMILLIONS)	REMANUFACTURING VALUE (EMILLIONS)	REFURBISHMENT VALUE(EMILLIONS)	OTHER REUSE VALUE (EMILLIONS)	MATERIALS SAVINGS (TONNES)	CO ₂ E (TONNES)
37.4	3.74	16.83	16.83	10,000	15,200

Remanufacturing in Context

True remanufacturing – bringing the product back to original equipment manufacturer (OEM) specification and with a warranty to match – is a minority option. In the UK this is estimated at less than 1,000 tonnes. Reuse with little or no refurbishment occurs more frequently, though charities and social enterprises are more likely to be involved by manufacturers.

An accurate evaluation of all reuse and remanufacture in the UK is difficult as the industry is highly fragmented; operations can be as small as a few pieces a year, and many operators act in this small ‘tail’.

The Furniture Reuse Network has 88 members engaged in office furniture reuse, but the majority of these are believed to collect under 100 pieces a year. A poll of trade association members and some of the largest UK operators suggests that actual reuse of office furniture is around 10,000 tonnes per year, the equivalent of 350,000 pieces. There is an active trade in the secondary market; that is, the passing on for reuse to lower value markets.

Cash-strapped targets include schools, charities, and start-up companies. Where OEMs are participating, a higher resale value can be achieved, but such instances are rare: only a single OEM has been identified as carrying out remanufacture or refurbishment in-house. Several other OEMs are involved with take-back schemes, but only through third parties, typically charitable organisations. The more effective of these schemes appear to be those involving products with high initial value and in applications where users may grow some level of attachment to them. An iconic example is that of the Herman Miller Aeron chair.

Trends

Several organisations are attempting to push the reuse and remanufacture of office furniture on a commercial scale, though these ventures are developing only slowly. Although rare, there is some action by OEMs to organise take-back of their own brand items in order to return them to ‘as new’ condition. More often these companies employ a third party, such as a charitable or social enterprise, and whilst this does divert furniture from landfill, the pieces are more often donated or sold at a lower price.

The recent economic downturn has led to a reduction in new sales. Manufacturers have typically lowered prices to attract business, with a consequent impact on the competitiveness of the reuse market.

Values

The structure of the industry, with a high proportion of charitable activities, means that an accurate estimate of the value of the reuse market is not possible. An alternative approach has been taken using the diversion of new sales as a proxy.

Limited information is available for differentiating between reuse and refurbishment. Several organisations classed themselves as reusing furniture when in fact they were carrying out operations characteristic of refurbishment, such as cosmetic adjustments and even re-upholstering. An estimate of equivalence between the two has therefore been assumed.

Barriers

Our research involved canvassing the views of operators in the sector regarding obstacles facing the reuse of office furniture:

- **Lack of demand** - Several organisations have attempted take-back schemes only to find they cannot sell recovered items. As reported above, this is alongside a lack of awareness of buyers that such schemes are in operation. Marketing of products appears poor.
- **Quality/technical issues** - Changing trends in office furniture design and fashion was highlighted as a barrier. Colour, shape and finish specifications are cyclical phenomena. An illustration of this is the recent demand for smaller desks driven by smaller computer monitors. There is opportunity to re-size older, larger stock, though this brings additional costs. Acquiring enough pieces of a particular type, or in suitable condition, also presented problems although these could be overcome if suitable warehousing were available to aggregate and smooth the variable supplies.
- **Financial** – Discounting of new furniture due to the economic downturn has reduced subsequent demand for pre-owned stock. The perception that refurbished stock

is of low quality translates into price resistance regardless of warranty. Some manufacturers considered that a remarketing element to their business would undermine new sales and, in particular, result in lower profitability. Whether this is true depends to a large extent on the initial value of new items, their market positioning and a business model that is translating furniture from a product to a service. This remains a challenge for many.

- **Logistics** – Collection of office furniture by OEMs can be difficult, as many do not have the capacity for storage. An equally important consideration is that of preventing damage to recovered stock. Current collection and storage practices reward speed of service over quality of stock. Motivation based on recognition of quality would lead to better logistics practices.
- **Other** – Liability issues could arise from the remarketing of items that had not undergone any form of checking or refurbishment. No interviewee could quote an example of such an occurrence, however. A more tangible issue is that of chemical use in fabrics and finishings, notably plasticisers and flame retardants. Refurbishers and resellers may not know which reagents were used in manufacture of their product, and may fall foul of more recent legislation in their use. Whether this is truly a problem for reuse as opposed to new sales has not been determined.

Opportunities

Whilst the barriers highlighted by office furniture stakeholders are significant, they are largely summarised in a single issue: Lack of current demand for remanufactured items. Causes of low demand include:

- perceptions of low quality
- lack of awareness of reputable quality items
- limited numbers of large, high-profile organisations that can instil confidence.

Government procurement represents a significant fraction of the market, amounting to around £65 million per year¹⁷. As of 2010, discussions are taking place to include an escalating proportion of reused or remanufactured furniture in the Government procurement policy in the UK, notably embedded in the

Government Buying Standards. Although it will not be published until late 2010, should this criterion be included, a market demand will be established that can mitigate some uncertainties for OEMs that are considering offering reuse services. For example, decisions on extra investment for capacity and collection will be quantifiable.

Even without Government influence, there are some schemes showing success; overseas examples have shown that remanufacture can be carried out as a successful business model. Kentwood Office Furniture in the USA operates a profitable business in which it offers new, remanufactured or reused (without treatment) furniture. In America, remanufactured products now hold a market share of 9% of all office furniture sector sales.

Pumps and Compressors

Pumps and compressors are grouped under the same industry classification code and are used in many industrial and domestic applications to pressurise and impel fluids. The manufacture of this equipment contributes £3.2 billion to the UK economy; this is equivalent to the size of the UK market as imports and exports are roughly equal in terms of value. The gross value added for this sector was calculated to be £1.1 billion.

Pumps are essential components in a vast array of equipment and form a core component in many different uses. A large variety of pump technology and specifications has been developed to meet the needs of these different uses.

By contrast, compressors have a more distinct set of applications, for example HVAC (heating, ventilation and air conditioning) systems or the transport of natural gas. Overall, the variety of uses for pumps and compressors means that, while the function and output of different units may ostensibly be the same, the internal mechanism can be very different. These differences are a consequence of differences in quality and performance for this equipment.

Within the UK there is a relatively large manufacturing base for these components, and large scale manufacture performed by a selection of large scale OEMs. Smaller OEMs typically manufacture more specialist equipment for minor or high performance uses.

As is the case with many manufacturing industries the market for this equipment has become more globalised in recent times, and cheaper imported units have gradually eroded the bottom end of these markets. However, the production of higher quality more advanced units remains a relatively buoyant area of manufacture in the UK.

Depending on the quality and usage of this equipment lifetimes vary from a few years up to decades. Various end-of-life scenarios exist for this equipment. Smaller pumps and compressors are often integrated into part of a larger piece of equipment and their fate is tied to the equipment's disposal as reclamation is not worthwhile. Larger pumps and compressors typically exist as more distinct units and can easily and economically be separated from other equipment. These higher value items show a much greater volume of reuse. If reuse is not viable these units will be scrapped, though some parts may be retrieved as spares.

Remanufacturing in Context

The design, mechanical nature and gradual technical development of pumps and compressors make them well suited to remanufacture and other forms of reuse. They are durable, and many components such as the casing will last almost indefinitely. Typically, failure is associated with moving parts such as the motors, bearings and shafts. These receive harder wear than other components; therefore these are the parts which most commonly require renewal as part of a remanufacturing or other process. In reality, low value units are often not worth salvaging for economic reasons.

At the other end of the scale, remanufacture of the highest value and most technologically advanced units is viable due to their inherent value, often tens of thousands of pounds. The processes carried out by OEMs and third parties in this sector are consistent with other industries (though a variety of terms may be used), and a warranty is typically offered as a sign of the quality of this process. These units can be worth as much as 70% of the cost of new.

In addition to this, remanufacturing provides the opportunity to upgrade components and install new functions such as monitoring

and logging devices. Between these extremes a spectrum of reconditioning, refurbishment and other reuse type activities occur. As in other sectors, factors such as value, condition and criticality define which level of reuse is viable.

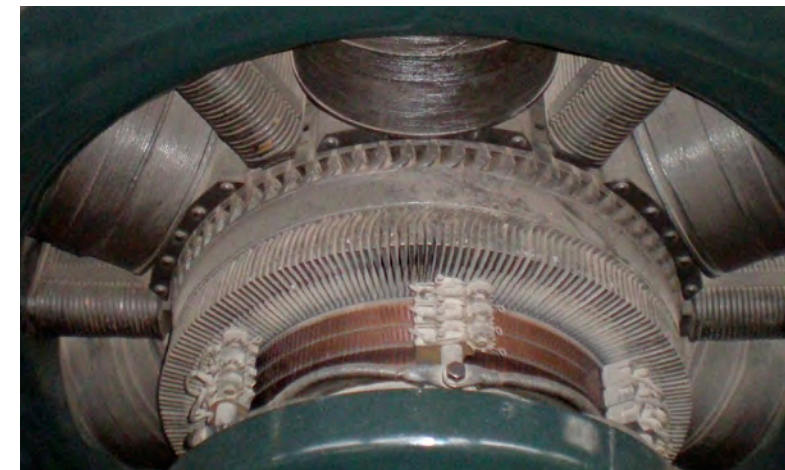
However, remanufacturing and reuse in this sector is more dependent on the product type than its suitability for remanufacture, and there is a large difference between the pump and compressor subsectors.

Within the pump industry remanufacturing is well established and understood. As described above, the construction of most pumps makes them suitable for remanufacturing. Lower value refurbishment and reconditioning work is also relatively common, again these processes are consistent with other industries in terms of the procedures involved.

The overall scale of this reuse market provides plenty of incentive for OEM engagement and they dominate the market in volumes and value. A recent shift towards more service based business models was noted, which further favours remanufacturing. Third party operators are also common, but on a much smaller scale than the OEM activities.

These independent companies offer products across the reuse spectrum, ranging from remanufactured down to reconditioned and refurbished. By comparison, remanufacturing and reuse in the compressor subsector is less well recognised. Historically there has been little scope for these activities and they were limited to small scale third party refurbishment and remanufacture.

More recently OEMs have established services which offer various



options for compressor and component reuse. Independent third parties are also improving their services to offer fully remanufactured products, and some now specialise in this equipment.

Trends

The previous survey highlighted differences in the penetration of remanufacturing of, and reuse in, pumps and compressors, noting that remanufacturing was far more established within the pump industry. This situation was still found to be true; however remanufacturing and reuse of compressors has noticeably grown over the past five years.

Overall, the remanufacture and reuse of pumps was found to be at a high and constant level, and industry interviewees expected this to continue. Remanufacture and reuse of compressors was found to be increasing, with OEMs now engaged and undertaking these activities.

Values

We estimate that reuse in the pumps and compressor market has a value of £260 million, based on a relatively static pump market and slight growth in the compressor market. Half of this value is associated with higher value remanufacturing activities; the remainder is evenly split between refurbishment and other reuse.

Barriers

Few barriers exist to the remanufacture and reuse of pumps as these activities are already central to the industry. The barriers below were identified as most important for the compressor subsector:

- **Awareness** – A lack of awareness of remanufacturing and reuse options in all sections of the compressor industry inhibits the development of these activities.
- **Market** – The demand and size of market for reused or

remanufactured compressors is comparatively small (partially due to lack of awareness). Therefore there is little incentive for businesses to offer these as part of their product range.

- **Costs** – The cost of remanufacture is often prohibitive for businesses, particularly for low value compressors. Cheaper products manufactured in Asia have also strongly influenced the potential value of remanufacture/reuse.
- **Core** – Obtaining high quality core in significant quantities is likely to become more of an issue in the future. The current trend within the industry is towards the production of cheaper but lower quality products; these are less suited to remanufacturing in the long term.

Opportunities

Within this sector there is certainly opportunity to develop the remanufacture and reuse of compressors. Maintaining pump remanufacturing at the current level is also critical. To achieve these goals several steps could be taken:

- **Establish best practice and standards** for the reuse and remanufacture of pumps and compressors. This could be overseen by a specialist interest group linked to a trade association.
- **Raise the profile of remanufacturing and reuse in the compressor sector** by determining and promoting the economic and environmental benefits. The pump industry could be used as an example to spur this on.
- **Provide incentives**, economic or otherwise, to purchase high quality remanufactured or reused products.

Rail Industry

The UK railway infrastructure consists of over 16,000 km of track and 2,500 stations, and annually is responsible for 47 billion passenger kilometres and 22 freight tonne kilometres. The operation of the industry can be divided into three subsectors;

infrastructure, passenger transport and freight transport. The infrastructure subsector, which includes track, bridges, signals and stations, is solely owned and operated by Network Rail. This organisation does not directly operate train services, but provides the infrastructure for other companies to run services on.

The passenger and freight subsectors are handled by train operating companies (TOCs) and freight transport companies respectively. These (mostly) privately owned companies operate the network's trains, coaches and other rolling stock services. Due to the high capital cost of this equipment (a standard new locomotive will cost in excess of £1 million) the operating companies do not typically own the rolling stock they use.

Instead, Rolling Stock Operating Companies (ROSCOs) purchase equipment which is then leased to the rail transport companies. There are four ROSCOs operating in the UK, these are typically owned by banks or investment firm due to the large amounts of capital required. In 2006 it was estimated that there were 12,500 trains and carriages leased from these ROSCOs. The leasing agreements typically include long term maintenance agreements, which is indicative of the well developed overhaul and repair activities within the industry.

This provides a cost effective way for passenger and freight operators to maintain and run a fleet of vehicles. The sales of rolling stock are dominated by a handful of large multinational companies including Bombardier, Siemens and Alstom. These companies most commonly act as final assemblers, piecing together individual components into a final product, which is then sold to ROSCOs.

The actual manufacture of individual components is commonly contracted out to smaller third parties, which specialise in the production of a particular part type. By contrast, purchasing within the infrastructure sector is more straightforward as OEMs are able to deal directly with Network Rail, rather than through different leasing companies.

Remanufacturing in Context

Remanufacturing, reuse and other aligned activities are commonplace within the rail sector, and these practices are well established and understood within the industry. The terms used

Table 22. Value of UK pumps & compressors recovery sector

TOTAL REUSE VALUE (EMILLIONS)	REMANUFACTURING VALUE (EMILLIONS)	REFURBISHMENT VALUE (EMILLIONS)	OTHER REUSE VALUE (EMILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
260	130	65	65	17,333	30,680

within this industry fit with the definitions discussed elsewhere in this report. Refurbishment was associated with cleaning up and replacing of a few worn parts whereas remanufacturing was found to be a more involved and labour intensive process, but resulting in a higher level of servicing.

Most remanufacturing orientated activity is associated with rolling stock as it undergoes heavy use and requires regular work to keep it running efficiently and safely. Extensive and regular maintenance is central to this part of the industry.

Industry contacts indicated that rolling stock is refurbished roughly every four years, and completely remanufactured at least once in its 30 year lifetime to ensure that it meets remains fit for purpose. These activities are typically performed through a service agreement with the ROSCOs which can be worth half the original equipment value. As part of these servicing activities components of trains and carriages will be repaired, replaced and modernised.

As a result of this, a healthy industry associated with remanufacturing components exists, particularly for components with moving parts which undergo heavy use. Some of these parts are commonly seen throughout the remanufacturing industry, such as diesel engines and pumps.

Other parts are more specific to the rail industry, for example wheel bogies. Typically remanufacturing is subcontracted out to specialist third parties, which have the core knowledge, skills and reputation to carry out this work. These organisations also need to be large enough to provide the volumes of parts required by the ROSCOs, and are often not linked to the FAs.

The operation of remanufacturing within this industry limits the scope for small, independent remanufacturers - these only operate in highly niche sectors, such as steam trains.

The diesel engines which drive locomotives are the most commonly remanufactured components. Engines are typically the part of trains which will wear out first, and a large proportion of older engines are remanufactured to keep trains running.

This is economic as newer engine designs do not always fit into newer trains, therefore remanufacturing is cheaper than the

alternative of purchasing a new locomotive. Railway engines, new and remanufactured, will be offered with a 500,000 mile warranty, indicating that this work is of high quality.

At end-of-life equipment from all sectors of the railway industry will be stripped down, and any reusable components and subsystems are removed for reuse wherever possible. Parts which cannot be salvaged will be sent for materials recycling processing.

It was stated that the motivation for this level of reuse, remanufacture and recycling was linked to financial motivations rather than environmental reasons. Reuse of infrastructure equipment does occur, but this is most accurately described as servicing and repurposing, for example by replacement of fastenings and insulators on older railways tracks, or repurposing of high speed tracks to less demanding low speed tracks.

Trends

Remanufacturing, refurbishment and reuse practices in this sector are well established and already occur on a large scale. These are fundamentally part of the way the industry operates, providing a route to minimise costs and improve efficiency.

The scale of these activities appears to have been consistent over the past few years, and without a major shift in the way the industry operates it is also unlikely to significantly increase or decrease in the near future.

Values

Within the UK there is an extensive level of refurbishment of rail equipment, particularly rolling stock - we estimate this to be worth at least £105 million per annum. Remanufacturing accounts for approximately £40 million of this, with lower value added activities being worth slightly more overall. The level of remanufacturing of static assets is difficult to gauge, and most activities appear aligned to maintenance. Therefore no estimate of this value has been made as it is likely to be misleading.



Barriers

- **Initial capital costs** - While remanufacturing or similar activities are common in many parts of this industry, it is difficult to initiate remanufacturing in new areas. For example, FAs wishing to start new remanufacturing projects are often prevented by the large capital costs required. Similarly this also presents a significant barrier for smaller organisations to become involved in this sector.
- **Safety** - A major influence on the UK rail industry as a whole is safety, which has an impact on remanufacturers. Railways are covered by a specific set of standards defined by the Railway Industry Supplier Approval Scheme. Both new and used equipment must undergo extensive non-destructive testing before accredited under this scheme. This ensures that equipment is maintained to the highest level throughout its working life. This places an additional but necessary economic burden on remanufacturers.
- **Technology** - A further factor which has made remanufacturing more difficult is the introduction of more modern rail equipment. As with many other sectors, electronic-based parts and systems are proliferating. This increases the difficulty of reuse and remanufacture due to the more complex equipment and requires different skills. It was suggested that this shifts some focus towards more refurbishment type work. However, as with the automotive industry, this could also open up opportunities for new services and new remanufacturers.

Table 23. Value of the UK rail recovery sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES STEEL EQUIV)	CO ₂ E (TONNES)
105	40	40	25	7,000	12,390

Opportunities

Remanufacturing and similar activities are already well established in this sector, and the industry is able to determine which process is most appropriate for a given part, normally based on economic factors. It is also well accepted, and as long as safety is assured there are difficulties caused by attitudes. However, industry could benefit from the introduction of harmonised standards and policies; this would help increase the confidence in remanufactured products.

Indirect influences, such as the targeted growth in rail use, for both passenger and freight, may also provide opportunities, as an increase in rolling stock quantities will be required to meet these growing demands. Therefore more service work will be required, boding well for remanufacturers operating in this area. As discussed previously, changes in technology may present some opportunities as this will provide remanufacturers with new types of component to work on. If a foothold can be gained in this area, it could present a significant opportunity in the future.

Textiles

Textile consumption in the UK is significant, with over 2 million tonnes used per year, and a value of around £23 billion. On a global scale, textiles are valued at over £500 billion¹⁸, with high social, economic and environmental impacts. 'Textiles' is a broad term, and for the context of this survey includes all UK carpets, clothing (both commercial, e.g. corporatewear and personal protective equipment (PPE), as well as domestic clothing), bed linen, towels, household linens (such as tablecloths) and curtains.



The consumption of textiles, and in particular, clothing, is vast in the UK, with discount branding and 'fast fashion' creating huge volumes to be disposed off. Most discarded textiles are still landfilled, with 540,000 tonnes of textiles disposed of to the household waste stream per year, and an additional 470,000 tonnes to household waste reclamation centres (HWRCs), which is almost entirely sent to landfill.

The UK imports most of the textiles it consumes, and as such, impacts of the sector are felt globally. With the wide range of materials utilised for production, resources are varied and wide spread. Typical materials include natural fibres such as cotton and wool, which require substantial land use, can be highly water intensive, and often use toxic chemicals in the form of pesticides or herbicides, or synthetic fibres, such as polyester, which are energy intensive and often sourced from fossil fuels¹⁹. As such, textiles have a substantial carbon footprint as well as impacting on many habitats and environments.

Remanufacturing in Context

For the majority of textiles, there is no remanufacture occurring, with the one exception (though on a small scale) being carpet tiles. The reuse of textiles, and in particular clothing, is improving, with optimum reuse happening through the resale of clothing for re-wear, but a secondary reuse option for unsuitable items is the cutting down to wipers used in many industries across the country. Current market values are high, due largely to the demand from overseas, typically less developed countries. The UK exports 360,000 tonnes of used textiles per year, with approximately 316,000 tonnes believed to be exported for reuse, as-is²⁰.

This has caused some debate in industry, however, as much of this material is exported unsorted, and therefore may contain foreign, non-textile objects. There is also concern that due to the nature of the export market, little is known about the end use of these items, and the potential for UK waste going to landfill overseas is highlighted by some stakeholders. Whilst no comprehensive study has been as yet carried out, the price paid for these textiles suggests that sending large proportions of it to landfill is unlikely.

Where reuse does occur, it is almost entirely due to third party recovery. Apart from the a few small scale operations, mainly

in the carpet industry, most collections are via either charitable donations, local authorities or commercial operators collecting via banks or door-to-door. The latter are often partnered by charities, but not always so.

Trends

Sales of textiles in the UK have seen a dramatic increase in recent years, though retail value per item has dropped substantially also. The rise of the 'discount' brands and fast fashion have created a very high disposal rate, with many usable, good quality items being thrown away. There is a general perception that 'cheap' clothing means 'poor quality' clothing, and this adds to the likelihood of consumers thinking an item is not of sufficient quality to warrant any further use at the end of its initial life. Textiles are forecast to be the quickest growing household waste stream between 2005 and 2020²¹.

Recent evidence suggests that textiles are growing as a percentage of household waste, but in absolute terms, a greater quantity is being recovered. An increase of over 200,000 tonnes has been seen in reuse of textiles since 2005, with 60,000 tonnes more reused within the UK.

Values

Reuse of textiles is either direct 'as-is' reuse, or involves cutting down to wiper rag. There are several very small, niche organisations, that take garments apart, redesign, and create new garments from them, but this is on a very small scale and not highlighted in these figures. This is a high noteworthy value application however. There is also a very low level (but growing) of carpet tile remanufacture in the UK. This is not yet at a scale to be included here, but does highlight opportunity and potential improvement for the future.

The carbon value for textiles is significant, as discussed above. However taking an 'average' value per tonne is difficult, as the actual figure varies greatly depending on what the material used is – ranging from less than 10 to above 30 tonnes CO₂e/tonne. Official Defra Waste Strategy figures for embodied energy and savings per tonne of textiles recycled, combines to give 20.6 tonnes CO₂e/tonne textiles. It is also important to note, however, that this figure does not take into account the transport costs associated

with export overseas. Most exported used textiles are shipped to Northern or Western Africa, Poland, and several other countries across the globe, reducing carbon savings from the figure quoted here. However, even considering UK reuse only, carbon savings are still within the region of 2.5 million tonnes per year.

Barriers

Several barriers exist in the reuse and remanufacture of textiles, though the reuse sector is growing. The heterogeneous market in clothing makes remanufacture on any large scale improbable, and resource intensive, so reuse is the only feasible option, apart from specific applications.

- **Quality of material collected at kerbside** - Kerbside collection of textiles is a useful tool for improving collection tonnages, but it is important that quantity increase is also at a sufficient quality level. A recent trend by local authorities is co-mingled collection, for separation at a Materials Reclamation Facility, or MRF. This can cause contamination of textiles, and they are difficult to recover from this level, for any valuable application such as reuse.
- **Collection issues/theft** - There are several methods of collecting textiles, including door-to-door collections and textile banks. With the value of worn textiles at the high price it has been over recent years, thefts and illicit collections have become frequent occurrences. This has caused some hesitancy by collectors to increase their target areas, or for new collectors to start up.
- **Manufacturer/retailer buy-in** - Reuse of clothing is a commercially profitable business, yet original clothing manufacturers, or retailers responsible for sales of the garments, are rarely involved in recovery. Globally, a few companies are known to offer in-store take-back, or even offer incentive schemes to encourage customers to bring back unwanted clothing, but this is only a small minority.
- **Competition from ‘discount’ retailers** - This is cited as a significant issue by many industry stakeholders, though sales of second hand clothing within the UK have seen more than a 100% increase in the past three years, so whether this is warranted is uncertain.
- **Potential ‘drop’ in market value** - The secondary textile industry is currently highly reliant on the overseas trading

market, and should prices fluctuate there is little control available from the UK. This has been a concern of the industry for several years, however, and is not so much a barrier as a potential issue for future consistency of collection.

Opportunities

The overall trend in recent years shows opportunity for reuse has grown, and looks set to continue to do so. As more organisations are becoming environmentally aware and landfill tax is continuing to rise, the incentive to recover textiles (either for the local authority or commercial users/retailers) is also growing, and several companies are starting to take some responsibility for their textiles. Carpet tiles are being remanufactured or refurbished on a small scale in the UK, but American examples show more success. Whilst the tonnage available for these processes may not be as large as for other textile product groups, the diversion of such bulk away from landfill can offer substantial benefit.

- **Textile availability** - 60% of clothing put in the household bin can be reused or recycled – 40% of which can be directly reused as-is²². This means there is significant opportunity for textiles to be pulled out of the waste stream, yet consumers need the convenience of collections in order to make use of this proportion of their ‘waste’. This was an effective method for other household recyclates and saw significant improvements in recovery rates. Collections need to be separate from other recyclables however; else they have a likelihood of contamination and subsequent unsuitability for reuse.
- **Partnerships** (between businesses, charities or local authorities) - The co-operation of local authorities and a third party to collect textiles separately at the kerbside is a sensible method of achieving greater collection tonnages. Other schemes that appear to be successful for improved recovery rates are examples (such as Marks & Spencer and Oxfam) whereby a retailer offers an incentive to return used own brand garments to a charity shop.

- **HWRC sites** - Deposits at HWRC sites are largely carpets, or carpet tiles, and quantities of these have risen significantly in recent years. Further work should be done to encourage the use of remanufactured or refurbished carpet products, in similar ways to overseas best practice examples seen in the USA.

Tyre Retreading

Tyres have long been a remanufactured item, as identified in our 2004 report, and can be broadly classified into the following broad areas of application:

- Cars, light commercial vehicles and motor-cycles
- Commercial and off-road vehicles
- Aircraft.

Recent comparisons by the OEMs have attempted to differentiate performance by rolling resistance – and by implication, fuel economy – but these comparisons have not been made on a like-for-like basis, as is likely to be confirmed by an imminent independent audit by AEA Technology.

From a technical standpoint, retreading is feasible and acceptable if properly monitored and controlled. Leading operators report that around 20% of car tyres that they receive are suitable for remoulding, which indicates both the degree of tyre abuse by the domestic user, and the rigour of the inspection process.

Each remould tyre is obliged to undergo a series of performance test prior to re-release. As a result, we believe that it is correct to consider this product as a true remanufactured item.

Remanufacturing in Context

Tyres are a prevalent product whose engineering has seen continuous advance over the last century in terms of wear rates, grip, wet weather performance, stability, rolling resistance and all round robustness. Retreading started around the 1930s as a

Table 24. Value of the UK textiles recovery sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES)	CO ₂ E (MILLION TONNES)
122	0	0	122	460,000	9.2

necessary remedial action for an expensive item, where new treads were casually bonded to worn tyre carcasses.

This inevitably gave rise to perceptions – with a high degree of truth – over quality and safety as a trade-off against price, but as with many commodity products, competition from low cost eastern markets has forced new tyre prices down, reducing the viability of domestic remoulding at least for the smaller tyres.

Perversely, at the same time, EU concerns for safety have forced improvements in production, marking and remould testing to unprecedented levels, meaning that issues of reliability and safety have never been lower.

Suitability for remould is initially indicated by the process standards (and product labelling) of manufacturers. (Note that not all tyres may be suitable for treatment, only those so constructed and labelled.) Secondly, each used return must be subject to inspection for obvious signs of sidewall damage, and may be subject to ultrasonic testing for internal integrity and band continuity. This testing regime is per tyre and in excess of new tyre test standards. The mechanical process of remoulding involves the removal of remaining tread to the sub-layer which forms the base for addition of a new layer of tread rubber. This is applied in a similar fashion to new tyre manufacture.

Remanufacturing should not be confused with re-grooving; this is commonplace amongst heavy commercial vehicle (HCV) and off-road tyres where new tyres are deliberately constructed with an over-thick tread layer. Once the 'normal' initial tread cut has worn down, a new tread cut is incised into the tyre perhaps two or three more times. The effects of retreading can therefore be achieved more simply at the expense of higher initial investment in the carcass and some impact on fuel consumption in moving extra mass.

Trends

The previous section alluded to the competing forces of low cost imports and rising domestic standards for remould processing. When taken with the alternative end-of-life options for tyres – such as energy from waste and crumbing for surfacing heavy commercial vehicle - the overall impact of this has been that

remoulding has become entrenched in those parts of the market where high degree of provenance, control of use and security of return supply can be exercised over the individual tyres.

Essentially, this corresponds to those tyres that are subject to fleet management services: logistics companies, in-house delivery fleets, pool cars, hire cars, earth-moving contractors, air fleet, military and the like, with a higher prevalence in the high-value articles.

Since the last survey there has been considerable rationalisation in the tyre remould market; the number of members of the Remould Manufacturers Association has fallen from thirty to less than twenty. There is a distinct shift of emphasis to servicing the cost-conscious fleet markets (HCV), abandoning the Light CV market, and to aerospace sectors where activity will follow underlying growth trends in aerospace.

Like many commodity products, there is intense competition in the lower value, passenger vehicle end of the market, especially from the far eastern and European suppliers. In the longer term, as living standards rise in developing nations, there may well be a swing back to remoulding in this segment, but it is likely to suffer from adverse public perception of quality without a concerted campaign with strong backing from OEMs.

However, since the last survey, there has been a growing trend



towards LCV use in home delivery and other rapid response internet expediting. These too are fleet-managed services, but are equipped with LCV-gauge tyres. Consequently, there is now a motivation to address this segment, which is currently not being met by the established providers. It does, however, represent a serious opportunity to change perceptions and build capacity in the segment, and could benefit from capital incentives.

Values

This is a sector where relatively robust National Audit Office data exist both for sales of new and remould tyres, the latest datasets extending to 2007.

The following tables (25 and 26, below) indicate the monetary and volumetric activity for new and remould tyres. The data reveal that both manufacturing and remoulding of car tyres accounts for a very small proportion of total use, reflecting the low status of remoulds. The category 'Remould manufacturing' by contrast effectively accounts for all remould use in this category.

The position is different in aircraft tyres, a more specialised area, where UK manufacturing is in fact an export activity and also accounts for a significant fraction of UK consumption.

A similar position exists for the construction vehicle tyre sector although a comprehensive analysis is not possible from these

Table 25. Value and volume of UK new tyres

UK MANUFACTURE (2007)	MANUFACTURE (£M)	MANUFACTURER UNITS (1000)	USE (£M)	USE UNITS (1000)
Car tyres	340	13,462	1,100	43,240
Aircraft	20.2	74.4	7.7	35.5
Lorries	0	0 (est.)	40.8	781
Agriculture	0	0	81.5	511
Construction	18.4	70?	50.3	200??
Other tyre use	0	0	65.3	2,455

Table 26. Value and volume of UK remould tyres

UK RETREADS (2007)	MANUFACTURE (£M)	MANUFACTURE UNITS (1000)	USE (£M)	USE UNITS (1000) NET
Car tyres	6 (est.)	430 (est.)	6 (est.)	430 (est.)
Aircraft et al.	7.9	31.3	4.8	-14.2
Lorries + buses	91.8	713	86.7	602

Table 27. UK tyre reuse market

UK REUSE (2007)	MASS (TONNE X 1,000)	USE (£M)
	30	40 (est.)

Table 28. UK tyre remanufacture materials & CO₂e savings

UK REUSE (2007)	MATERIAL TONNES (1000)	CO ₂ e TONNES (1000)
Remould	40	147 (est.)
Reuse	30	120 (est.)

data. Lorry and bus tyres are not manufactured in the UK but, as revealed from the survey, ‘Remould manufacturing’ represents virtually the entire remould activity within the UK.

Reuse also occurs within certain markets where part-worn tyres are remarketed. The source of part-worn tyres is almost exclusively passenger cars which are going for end-of-life treatment. Estimates of the volume of part-worns are available from a recent survey conducted by Oakdene Hollins for WRAP and are judged to be around 6% of the tyre disposal inventory (which approximately corresponds to the UK use market). On this basis, therefore, the current reuse market is estimated to be as shown in Table 27. The materials and CO₂e savings from remanufacture are estimated as shown in Table 28.

Barriers

In the passenger car (LCV) market, low priced imports are perceived to be the greatest barrier to use of remoulds. This is undoubtedly enhanced by a persisting view that remoulds are a second-best choice.

In the delivery van tyre market (car-sized tyres), there is undoubtedly a demand for remould tyres, but with the collapse of the underlying passenger car capacity there is a shortage of capacity amongst credible suppliers. There are few if any technical barriers to reuse within HCV and off-road vehicle segments. Opportunity is limited by the awareness of fleet managers. Contract fleet managers appear to be well-informed compared to in-house fleet managers. This awareness may also be exploited to drive cross-selling of other remanufacturing purchasing opportunities.

One interesting potential barrier exists in regard to the utility value of remanufactured road tyres. To date, remoulding has

been marketed on the basis of cost saving per tyre. However, data regarding the life and fuel efficiency impact of remould tyres is sparse or well guarded.

Attempts by CRR to determine these important factors, whilst supported by end-users, have not been met with open arms by remoulders. There is no barrier to reuse within aerospace. The issue outlined above is likely to have negligible impact since wear associated with taxying is negligible compared to the frictional effects of a landing.

Opportunities

It appears that use of remoulds is well-established within the HCV markets (heavier duty tyres), especially where fleet management companies have an interest in price per performance. However, our research shows that LCV-type tyres, as used on the smaller delivery vehicles typically used in home shopping deliveries, do not see the same treatment.

Although it is certain that a demand exists, perversely it appears that remoulders are not willing to supply to the market despite being presented with named customers; this is attributable to the economics of investment in the smaller tyre size remoulding equipment at the scale required, which appears to be a stretch for operators interviewed.

White Goods

This section examines the reuse and remanufacture of white goods, which incorporates washing machines, fridge/freezers and dishwashers. White goods are usually used until the end of their useful life. They are not regarded as a being a subject to fashion or rapid innovation. Indeed, the prevalence of fitted kitchen units with embedded white goods that have replaceable fascias is reducing the perceived requirement to replace these units until they become uneconomic to repair.

Repair and remanufacture of these units, therefore, is generally commercially non-viable. In the case of fridge-freezers, the arisings of working units is further reduced because old working fridges are generally retained as secondary units for cooling drinks.

Remanufacturing in Context

Social Enterprise Schemes

In general, due to the lower quality of older appliances, the market is limited to disadvantaged and low income households. Charitable organisations are specifically run to cater for this market sector. There are approximately 400 of these schemes nationwide. These organisations are heavily dependent on subsidies either from government, Europe or charitable funds such as the National Lottery. In addition to providing low cost white goods to disadvantaged households, these schemes also provide employment for the long-term unemployed and socially disadvantaged by providing skills and training programmes.

The Furniture Reuse Network (FRN) is an umbrella organisation for over 250 social schemes which reuse and remanufacture furniture. It estimates that affiliates reuse and remanufacture 2,000,000 items per year of which 500,000 are appliances. Schemes from the FRN are primarily run for the benefit of low income and disadvantaged households. To ensure that the correct people receive the goods collected, the sales prices are set at a nominal fee, sometimes as low as £5 for a washing machine.

The sale of these goods at this price is restricted through the housing association. Schemes such as the Sofa Project in Bristol have a dual pricing scheme where disadvantaged households can claim tokens through the council and purchase remanufactured items at a lower cost than they are sold to members of the general public. Recently, grant funding for charities has changed from supplying low-cost products and diversion of material from landfill to training and job creation activities. This has led to a shift in activities to include long term unemployed and disadvantaged groups as part of their workforce.

The FRN state that the demand for low-cost appliances significantly outstrips supply. Traditional competition with local commercial reuse centres for equipment has dropped; however, competition for units with large scale exporters is reducing supply. There are concerns over the final destination of these units with little or no regulation once they are exported. Upcoming WEEE Advisory Board standards on the shipment of electrical products may reduce these fears.



Commercial Enterprises

In the past, second hand appliance retail outlets were common place on the high-street. However, the growing network of social enterprise schemes in the UK is competing with and replacing this commercial sector. Also, the drive for lower priced new goods is reducing margins on the sale of second hand appliances.

The commercial operators are disadvantaged due to the absence of 'good will' afforded towards charities resulting in preferential donation. Also, the ability of charities to apply for supplementary grant funding means charities can sell appliances at a loss.

Factory Seconds

There is a large (and relatively difficult to estimate) market for selling returned, damaged and end of line goods. With the majority of appliances being imported, there is little infrastructure in the UK for repairing and returning damaged goods to customers.

Cosmetic damage, such as scrapes and scuffs during transport, are difficult to repair as the damage can be to panels welded to the chassis. Mechanically, the units maybe in perfect working order. Legally, however, they cannot be sold as new and are consequently less attractive to customers.

There is a competitive market for factory seconds both from the private sector and charitable organisations. Agreements between retailers or manufacturers and reuse organisations have been developed to resell these units. Products are sold through a variety of outlets including on-line auction sites and retail discount centres.

Table 29. Appliance refurbishment

APPLIANCE	NUMBER REFRUBISHED
Cooling appliances	105,000
Washing machines	104,000
Dishwashers	40,000

For the charitable sector, legitimacy and professional operations are a problem in reaching large electrical suppliers. One scheme which aims to encourage business from corporate retailers is FRN-Enterprise, a separate body that accredits and regulates larger furniture reuse charities. The body performs a similar audit to ISO9001 checks, thus ensuring that the services offered by the charity will be of sufficient quality.

Accelerated Replacement

There is evidence that in the majority of cases, energy consumed in use for energy using product is greater than that required during its manufacture and disposal. Particularly with white goods where there have been significant energy efficiency gains over the last few decades, it is important that the whole life costs (the manufacture/ remanufacture + energy in use + end-of-life) are considered.

In the case of older appliances, the advances in energy efficiency over these units may be so great as to warrant scrapping the old unit and buying new, even with the associated savings achieved through remanufacture. It is broadly accepted that replacement with newer equipment will improve whole life cycle energy efficiency. However, charities argue that the financial cost of replacement of old with new, even with the additional energy cost of operating the older appliance, is greater than buying a low-price remanufactured item.

The extra environmental burden imposed by keeping older appliances in service must be balanced against fundamental needs of households.

Remanufacturing Process

The quality of the items collected varies widely depending on the method of collection. Anecdotally, the majority of refurbishing and remanufacturing activity is carried out by the third sector.

Within this sector, up to 80% of goods collected from residential accommodation are suitable for remanufacture. However only 1-2% of goods entering civil amenities sites are suitable for remanufacture. Goods entering the CA site are of low suitability because:

- Appliances disposed of directly to CA sites are usually poorer quality or older than those donated from the household to a remanufacturing scheme. Most households which dispose of appliances will assess their quality; where they are deemed to be unfit for reuse, they will be disposed of through CA sites
- Poor treatment by doorstep bulky waste collectors causes damage to the appliances
- Exposure to the elements can lead to degradation of the core at CA sites.

Social enterprise schemes prefer to collect the appliances directly from the donating household. The FRN is keen to emphasise that these appliances are being 'donated' for a second use and not simply an easy route to the disposal of the appliances. These schemes employ a large number of disabled and disadvantaged people.

To offset the increase costs the charities are able to apply for grant funding for employment. The funding source itself has changed focus from helping the disadvantaged to job creation. The third sector has adapted its approach accordingly.

The FRN has drafted a code of practice for testing and remanufacturing electrical equipment. It has distributed the document to its members who must use the guide as a framework to repair and resell electrical items. This document is designed to give traceability for the disposal and reuse of electrical appliances and also ensure that the members of the organisation are operating to a minimum standard.

Generally, the procedure followed for remanufacturing white goods is:

- The condition of the unit is determined over the phone prior to collection from a household, whereas items are cherry-picked by visual inspection from a CA site.

- Collection of items as they are deposited from a CA site is preferred to minimise damage from the elements
- Suitable items are returned to the workshop
- Further visual/working inspections are performed by an engineer, any unsuitable at this stage are recycled. In-house knowledge is used to determine which makes and models are suitable for remanufacture
- The appliances are cleaned
- The units are then electrically tested
- The units are then tested for functionality. For example, washing machines are run on several different washing cycles
- Any repairs are carried out as necessary. Again, in-house knowledge is used to judge if the repair to an appliance is economic
- The units are then safety tested.

Trends

The reuse of factory seconds is a sustainable business that is clearly beneficial to both reusers and end customers. The market for these goods is not limited to disadvantaged households in that sales are made to the general public. The scope for growth is limited by the supply of goods from manufacturers or retailers; therefore any increase in this area is only likely to occur from increased sales on new units.

The industry expects growth in dishwasher sales but clearly, other than increases in population and number of households, there is limited scope for increases in the stock of washing machines and

cooling appliances. The remanufacture and refurbishment of white goods by the third sector is largely limited by supply. Charities claim that they have the ability to sell significantly more stock than is currently available to sell. Obtaining suitable core for these organisations is a major problem.

Values

Reuse of Factory Seconds

The fragmented nature of the market makes measurement of the market size difficult. Clearly the volume of sale will largely be dictated by the return rate of product through retailers. We can determine the volume of returned stock by estimating the percentage of returns from new sales. New sales were determined by analysing average lifetime of appliance and the current UK stock. This process assumes a steady state (i.e. the number of appliances being used is not increasing).

Table 30 below shows the breakdown of white goods, their relative market penetration and their life expectancy.

Refurbishment by the Third Sector

The FRN estimates that it processes close to 250,000 domestic appliances yearly. As FRN represents 85% of the social enterprise reuse market in the UK, this implies a total processing of approximately 295,000 items. It is difficult to estimate the split between straight reuse and refurbishment but, anecdotally, the majority of units are refurbished. Based on expected arisings of

individual appliances, Table 30 below breaks down the estimated number of refurbished appliances in the UK.

Barriers

The main barriers to increasing reuse in this sector are:

- **Obtaining good quality core.** Consumer demand for either reused or remanufactured units is strong, obtaining high quality core, particularly for refurbishment. (Collection availability of collection services location) is critical to increasing volumes through this route.
- **Variation in availability of grants.** Charitable organisations rely on grants to operate. Clearly changes in funding requirements and how money is allocated have an effect on the level of reuse possible.

Opportunities

There are opportunities to increase the reuse of refurbished white goods. These are largely limited to disadvantaged households and generally require charitable donations (both in terms of core and subsidies for refurbishers). There is a healthy market for both demand and supply of factory seconds.

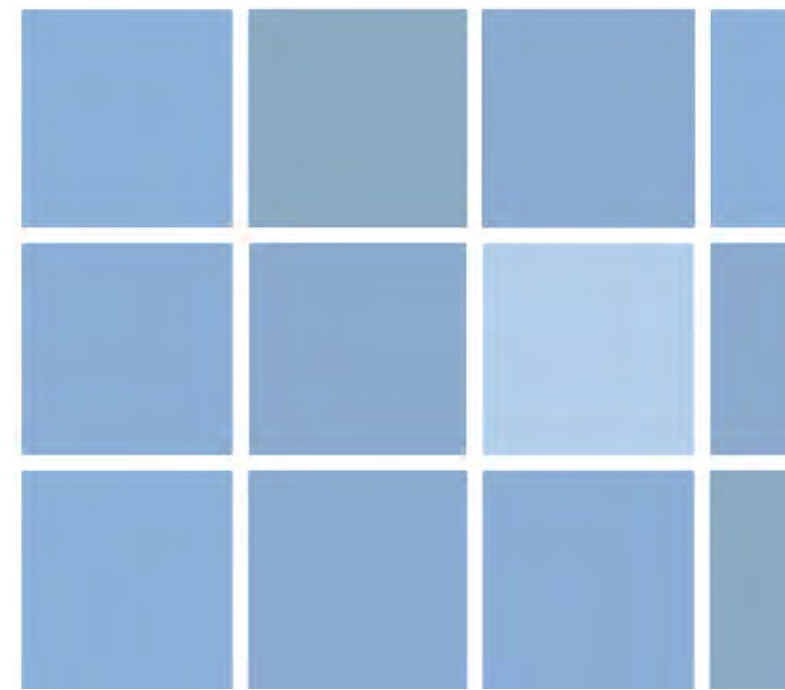
Table 30. UK white goods (age, market penetration and life expectancy)

APPLIANCE	AVERAGE AGE (YEARS)	% MARKET PENETRATION	NUMBER IN UK STOCK	NUMBER REPLACED YEARLY	ESTIMATED NUMBER OF RETURNS / SALES
Cooling appliances	11	97	23.4	2.1	21,000
Washing machines	9	95	22.9	2.54	25,400
Dishwashers	9	37	8.9	0.99	9,900

Table 31. Estimated value of UK appliances recovery sector

TOTAL REUSE VALUE (£MILLIONS)	REMANUFACTURING VALUE (£MILLIONS)	REFURBISHMENT VALUE (£MILLIONS)	OTHER REUSE VALUE (£MILLIONS)	MATERIALS SAVINGS (TONNES)	CO ₂ E (TONNES)
37.4	0	25.7	11.7	22,052	46,970

Based on ICER data: 60 kg per fridge, 85 kg per washing machine, 70 kg per dishwasher, average value of a new appliance: £350 fridge, £325 washing machine and £380 for dishwashers. Reused prices are 60% of new and refurbished and 30%.



7 The Future of Remanufacturing in the UK

In 2002, Oakdene Hollins' prime motivation for investigating remanufacturing was a desire to find the new frontier of so-called resource efficiency measures beyond the then current vogue of recycling. It was clear that recycling was driven by an agenda other than resource efficiency and carbon reduction, namely landfill diversion.

In time, however, the various agendas have become more aligned, with recycling options having to leap multiple environmental and legislative hurdles to obtain state support. This is a welcome development. Remanufacturing and reuse, however, whilst no longer the 'Cinderella' options for end-of-life management, are far from the centre of resource efficiency initiatives.

Support for CRR's activities in helping to promote increase in reuse has always sat uncomfortably within the Government's conventional waste strategy. This is because these focus on waste – largely as low grade rejects of a once-through manufacturing and consumption processes. Reuse, on the other hand, is distinctly concerned with the enduring value embedded in manufactured goods and the preservation of form and function with minimum additional input appropriate to the needs of the next user of the product. This is a system driven by commercial opportunity. The ensuing focus on cost generally means that that which is not reused is almost certainly recycled or diverted from landfill. Hence, although remanufacturing has substantial impact on the carbon and materials impact of manufacturing, it has little impact on conventional government waste metrics based on landfill or recycling uptake.

The truth is that remanufacturing has rarely been driven by environmental concerns. Rather it is characterised by the following:

- A diversity of business models other than make-and-sell.
- Closed loop manufacturing systems which stress the importance of cost-effective product recovery
- A shift in skills towards the more complex diagnostic and remediation aspects and with higher labour content than manufacturing.

The material consequences of these are:

- Generally higher business robustness than make-and-sell – business can flex between manufacture and remanufacture to service an installed base
- Simultaneously satisfying concerns of buyers and sellers – closed loop systems can de facto meet end-of-life obligations; motivate longevity for through-life cost reduction; promote product redesign for reuse; and satisfy material security concerns for sensitive products by securing returns
- A substantial consequential materials and energy benefit per product use cycle compared to one-shot use, with these elements replaced by higher skilled labour – so-called green jobs
- A fostering of a local or regional skill base employing engineering and manufacturing capabilities – these can out-manoeuvre foreign suppliers through the ability to offer highly responsive product support options.

As a result remanufacturing appeals more to the emergent agendas of the Departments of Business Innovation and Skills (BIS) and Department of Energy and Climate Change (DECC). The former in particular has been charged with the delivery of the New (green) Industries, New Jobs Agenda (NINJA) and has promoted the concept of product servicisation.

It is ironic at time when service industries have been criticised for their apparent role in the financial crisis that we should now exhort them as a means of recovery.

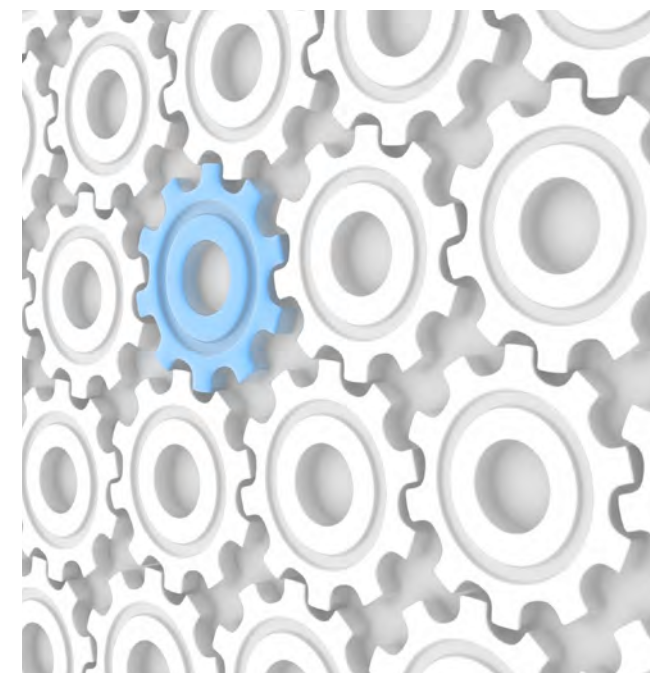
However, it is important to note that these services are very much based on the manufacture, use, service and upgrade of capital goods, not an ephemeral, virtual or discretionary experience associated with travel, personal care, leisure or media.

Therefore, at the strategic level, we believe that businesses based on remanufacturing and reuse have a bright future and should receive increasing Government interest. As to how those businesses engage with customers, we believe that the attributes of materials and energy efficiency, so long the missed opportunity of remanufacturing and reuse, now hold the greatest potential for creating a shift in perception and uptake.

Further stimulation of product reuse can be motivated by range of actions including:

- Improvement in, and uptake of, remanufacturing standards to drive perceptions of quality within sectors.
- As has occurred in recycling, a preference for promoting capital investment in businesses embodying the highest resource effectiveness practices i.e. based on reuse and remanufacture. This might take the form of capital grants for remanufacturing equipment
- A wider commitment to accounting and business practices on the purchaser side that correctly value whole-life purchasing and resource use impacts. The accountancy and purchasing trade bodies (CIMA and CIPS) must rise to the challenge of new costing based on money and carbon
- A wider promotion of models of resource-effective business practice amongst future business leaders, especially before conventional business paradigms have become too deeply rooted.

These present challenges for a range of agents, not simply those involved in remanufacturing itself.



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The Centre for Remanufacturing & Reuse

The Centre for Remanufacturing & Reuse (CRR) was established in 2006 to support and promote, where appropriate, the activities of product remanufacturing and reuse. It offers commercial services in market studies, carbon footprinting, reuse standards, purchaser advice, business model development and knowledge transfer.

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Remanufacturing is the process of bringing end-of-life products back to life by repairing, refurbishing, upgrading and/or replacing parts. Remanufactured products are provided with a warranty matching that of a new product, ensuring customer confidence.

The CRR's website www.remanufacturing.org.uk provides comprehensive and free interactive information, including:

- who is remanufacturing
- what products can be remanufactured
- how to remanufacture
- the benefits of remanufacturing.

The CRR is managed by Oakdene Hollins, a clean technology and resource management consultancy based in Aylesbury, Buckinghamshire (www.oakdenehollins.co.uk).

The CRR believes that product remanufacturing and reuse:

- is vital to the conservation of resources including materials and energy
- presents benefits to both the environment and businesses
- boosts skills, employment and economic activity in the UK.

For additional information please contact:

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