CENTRE FOR REMANUFACTURING & REUSE

Policy Report

A Review of Policy Options for Promoting Remanufacturing in the UK

October 2008

Oakdene Hollins

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1 Executive Summary

We know that remanufacturing can offer very significant resource savings when compared to recycling or disposal. There is an existing industry concerned with remanufacturing, which is worth £5 billion in sales and is concentrated in the automotive, aerospace and defence sectors.

In many respects it is similar to the recycling industry in the 1970s when most of the activity was centred around metals and paper. The question then was how to expand these activities into additional material streams. Today, a wide range of instruments have been used to expand the recycling sector, from Landfill Tax through to PRNs and capital grant schemes. In some cases, these recycling policies are now acting as a barrier to the uptake of remanufacturing.

The expansion of remanufacturing activity also faces a number of economic barriers caused by market imperfections. These can be summarised as fundamentally transactional problems surrounding:

- Collection, sorting and disassembly. Associated costs are driven by insufficient numbers of product returns of the right quality available for remanufacturing (core) which in turn is primarily caused by:
  - the lack of available technical information to facilitate disassembly, and
  - the existence of an 'incumbent' collection infrastructure (partly publicly funded) which is geared to meeting the needs of recycling.
- Insufficient market demand. Prospective purchasers have difficulty in assessing the functionality and performance of a remanufactured product, which gives rise to perceived high risk which translates into an expectation of a significant compensating price discount that cannot always be met.

Our research identified that that those OEMs undertaking remanufacturing have solved these problems by integrating product design, manufacture, use and recovery activities. This means that the benefits of design changes, collection arrangements and other organisational investments are fully captured. In contrast, in a market-organised third party remanufacturing model, the benefits of investments in design changes by OEMs may flow into third party remanufacturers' profits. Equally, investments by third party remanufacturers in collection arrangements may not result in the recovery of products that can then be remanufactured.

Any policy interventions should learn from this and seek to replicate and/or reinforce these successful commercial relationships.

We propose that any policy in the field of remanufacturing should therefore focus on:

- The remanufactured product. We cannot know *ex ante* what can be remanufactured. We should therefore rely on the ingenuity of remanufacturers to determine that.
- The 'purchasing decision', since we think that this is where demand for remanufactured goods can be stimulated, which will initiate supply-side investments.
- The 'disposal decision', as it at this transaction point that appropriate incentives can be given by remanufacturers/collectors to ensure the 'correct' routing of remanufacturable products, which will 'pass through' to OEMs to design products which are potentially remanufacturable.

However, any policy intervention must take into account the overarching policy objective which is: greater resource efficiency. We therefore believe it would be premature to employ economic instruments to promote remanufacturing e.g. reducing VAT on remanufacturing activities, for the following reasons:

- The evidence base to establish which classes of product will yield the greatest resource benefit through remanufacturing has barely been established. Until this is known we cannot discover where in the value chain an intervention would be most effective.
- In some cases, society may in fact be worse off by encouraging the extension in life of energy-using technologies that have been overtaken by more efficient ones. There may therefore be a negative innovation effect.

Since the overall policy objective is resource saving, we believe that it should be possible to develop one or more elegant policy tools that respond to changes in market prices as well as the various carbon benefits offered by different product classes.

2 Introduction

It is generally accepted that optimal results with regard to public ‘bads’ such as CO_2 emissions are not achieved via decentralised markets, and this therefore represents a market failure which needs to be addressed by public policy.

Remanufacturing is of importance because it offers the opportunity to recover the materials, energy and water equivalents used during the original manufacturing process. It can therefore deliver significantly greater carbon benefits than materials recycling, as it does not involve the destruction and reconstitution of products, which itself consumes energy.

As a result, similarly to re-use, remanufacturing sits at a higher level in the waste management hierarchy than materials recycling.

In this report, we try to answer two key questions:

- Are market imperfections or failures operating to prevent an expansion of remanufacturing activity in the UK economy?
- If there are market imperfections, what are the appropriate policy instruments to overcome them?

We have therefore divided this paper into three parts:

- An explanation of what we mean by ‘remanufacturing’.
- An elucidation of barriers that appear to exist – this section will also explore why some manufacturers adopt this business model whilst others do not.
- An evaluation of the range of policy interventions that may be applicable.

The report draws heavily from OECD research and analysis in the area of development and evaluation of policy instruments to promote environmental aims.

3 What is Remanufacturing?

3.1 Definitions

Remanufacturing has been practised for at least 100 years in the UK. A study by Oakdene Hollins (2004) estimated that its turnover value could be as high as £5bn, employing around 50,000 people. It is concentrated in the aerospace, automotive and defence sectors.

Remanufacturing is a process similar to manufacturing. The starting point is a product, comprising components (themselves products), that has reached the end of its useful life (i.e. it no longer performs the function it was designed for), but which may not yet be defined as 'waste'. The failed or worn components of the product can be remanufactured, repaired or replaced so that the utility value of the whole is restored.

Remanufacturing therefore resurrects the functionality of the product with minimised energy and virgin material inputs. Hence it can be seen as a transformative process: used products are turned into useful components that are then reassembleda. To that extent we are more likely to see remanufacturing in respect of complex products comprising different parts and materialsb.

Some of the literature grapples with the distinction between remanufacturing, repair, refurbishment, rebuilding and reconditioning. In most cases, the differences are minimal because these end of life treatments share similar objectives i.e. the restoration of the original product to as near as possible original condition. They are however all significantly distinguishable from recycling, which is about the destruction of products into their constituent materials.

As a result, depending on the context and history of remanufacturing in particular industry sectors, terms are often interchangeable. For example, 'rebuilding' is often used instead of 'remanufacturing' in the automotive sector. A key point is that remanufacturing is one destination amongst many after the end of a product's first life. Figure 1 below shows the alternative destinations available.

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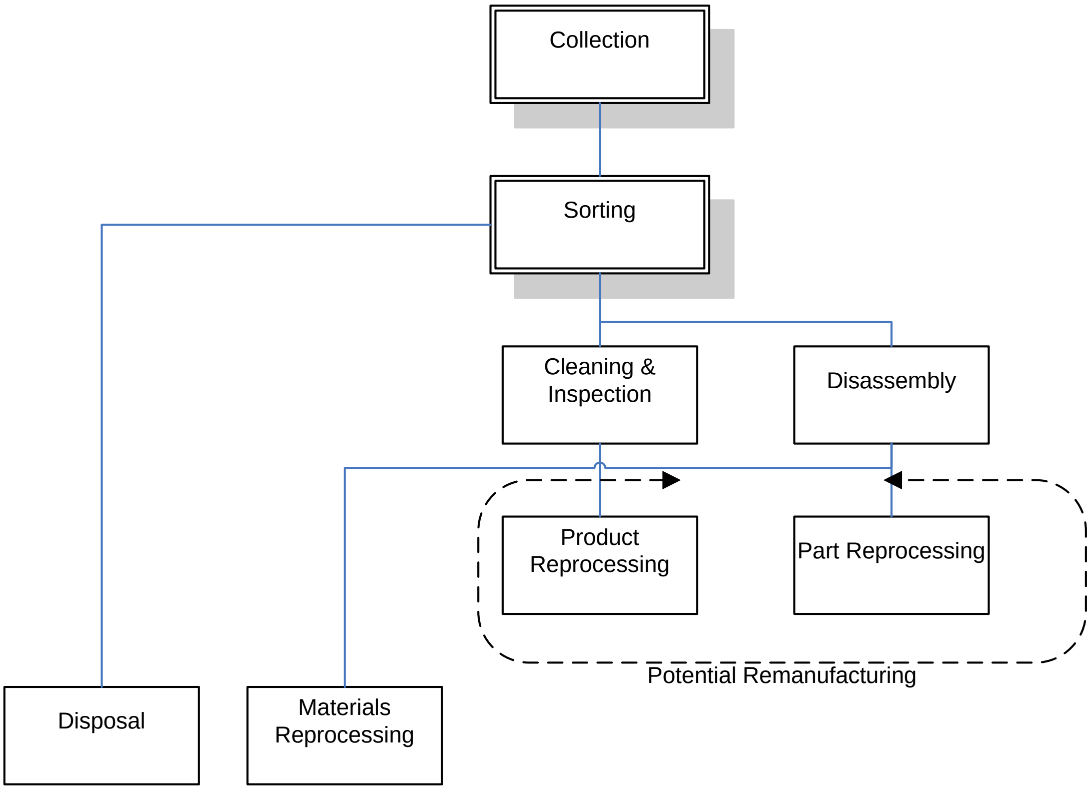
[a] Nakajima 2000

[b] Tojo 2001

Fig. 1: Used Goods Processing



3.2 Key remanufacturing attributes

There is also a considerable quantity of literature about the key ingredients of a successful remanufacturing operation:

- **A supply of returned products**, sometimes termed 'core'. A successful remanufacturing operation requires a regular flow of returns, which themselves must be of sufficient quality to be remanufactured successfully.
- Linked to the above, a **collection and recovery process** and infrastructure in place that involves careful **deconstruction and/or sorting**. This process is therefore likely to be more labour- and capital-intensive than that currently employed in relation to recycling, because the potential functionality of the product needs to be preserved.
- Inspection, disassembly, cleaning and reassembly by **skilled personnel** which enables malfunctioning or worn components to be identified and remanufactured. This requires a good understanding of the product and access to a manufacturing/engineering skills base.

- Market demand at a **price** that reflects the cost of remanufacturing but which is still competitive in comparison to a new product. Typically remanufactured products sell at a price at least 20% and maybe 50% less than brand new products[a].
- There is **customer acceptability** of remanufactured products, which must demonstrably deliver a required functionality.

3.3 The organisation of remanufacturing

The activities identified above appear to be organised in one of two ways:

- By the OEM or final assembler (FA). The OEM/FA organises collection and recovery of returns, undertakes disassembly and reassembly and re-selling. The relationship between user/customer does not therefore end with a sale but is developed over the life of the product. Caterpillar operates a good example of this, whereby the customer trades in products to dealers at the end of their useful lives.
- By the market. The market organises remanufacturing as a separate activity via independent third party remanufacturers. A good example is the automotive sector, in which remanufacturing of components is commonplace and there is a market-organised system of recovery of used products.

There is also a hybrid model in which the OEM/FA and an independent third party remanufacturer maybe tied by contracts, or accredited or licensed (e.g. Nortel and Paragon in respect of telephonic equipment).

In much of the literature, remanufacturing seems to be defined in terms of the OEM model i.e. as good as new with concomitant assurances or warranties[b]. For example Parkinson & Thompson (2003) emphasise that remanufacturing must avoid becoming "merely…the analysis of used goods reprocessing and not remanufacture, the key to which is the concept of as good as new and the concomitant assurance activities".

It is not clear why we should define remanufacturing in terms of a particular business model focussing on how remanufactured goods are marketed to prospective purchasers (i.e. 'as good as new'). In fact to define remanufacturing simply as 'used goods processing' may be a more useful way of looking at the practice, since it captures the aspects of sorting, inspection and cleaning which,

[a] Business Week 2005

[b] Michaud & Lierena 2006 and others

although possibly common to recycling, is integral to and a key pre-requisite for the remanufacturing process.

3.4 Comparison of OEM and market organised models

The key distinctive aspects of the market organisation of remanufacturing as compared to that of the OEM/FA are that:

- There is sufficient technical knowledge in the public domain or technologies have been developed by third party remanufacturers which enable ease of disassembly and reassembly.
- There is a developed market for returned 'core' or parts.

Unsurprisingly, there can therefore be considerable conflict and competition between OEMs/FAs and third party remanufacturers. The knowledge embodied in a product, its design and how it is assembled may be unique to the OEM, indeed it may be its only unique resource. So an OEM/FA may be concerned that a market-organised system is a threat to revenue streams, through loss of intellectual property (IP), reputation (substitution of inferior quality) and cannibalisation of sales. An example is the current printer cartridge market.

However, entering remanufacturing activities may be employed as a defensive business strategy for a market incumbent. Two examplars referred to in the literature[a] are Caterpillar and Xerox. Both these firms were market leaders and were losing market share before they embarked on new business models which included re-manufacturing. Remanufacturing enabled these companies to leverage their large sales force / dealer networks to retain customers, cut costs and increase market share.

Research point: Investigate how Xerox and Caterpillar undertook remanufacturing activities as a response to external competition in order to understand the key factors that enabled the adoption of a business model that included remanufacturing.

A number of incentives have also been identified in the literature[b] for other OEMs to undertake remanufacturing activity:

[a] e.g. see Giuntini & Gaudette 2003, Nakijama & Vanderburg 2005 and Kerr & Ryan 2001

[b] e.g. Toffel 2004

- Remanufacturing enables the maintenance and development of a long term relationship with a customer, thereby leading to a future stream of product sales and other services. By developing a whole life cycle view of the performance of their product a remanufacturer can create a learning feedback loop which aids future product design.
- It enables materials to be recovered and therefore results in saving the costs of virgin materials.
- It can protect the brand. For example Sun Systems uses its IPR as the reason for choosing its remanufactured products[a], a key differentiator from the third party remanufacturer.
- Remanufacturing provides an image of environmental sustainability.

With these apparently strong drivers, we would expect that OEMs/FAs to be more numerous in the remanufacturing market. There is limited data available, but it is estimated that only 5% of the remanufacturing market in the US for example is controlled by OEMs[b]. The remaining 95% is therefore organised by the market through third party remanufacturers. It is probable the same ratio operates in the UK.

Research point: Investigate the relative proportions of remanufacturing activity in turnover terms undertaken by OEM rather than third party remanufacturers.

Recommendation: Maintain an annual record of total remanufacturing activity in the UK by sector in turnover terms. This would be a useful measure of the success or otherwise of policy interventions to encourage remanufacturing activity.

[a] IDC 2004

[b] Lund 1996

4 Barriers

Where a product has a positive economic value at end of life (i.e. the costs of collecting, sorting and reprocessing the product are lower than the market value of the remanufactured product) it would be expected that market forces would generate significant remanufacturing activity. However where the value of recovered product is negative (i.e. the costs of collecting, sorting and reprocessing the product are greater than the value of the remanufactured product and the savings in virgin materials) one would not expect remanufacturing to take place.

In this section we will examine what are the likely factors that contribute to the low end of life value and high collection and reprocessing costs described above. Although more micro-level analysis is required, they can be classed as mainly transactional/informational problems. From other areas of study (e.g. the 'no regrets' potential in respect of energy efficiency[a]) these do not necessarily need to be high at an individual firm level to prevent adoption, but they have significant social costs when aggregated together.

There are three transaction points where barriers can exist.

4.1 Collecting remanufacturable products

For many firms the collection of products, often termed 'reverse logistics', is outside their competencies. The prevalent logistics supply chain is geared towards one-way movement from manufacturer to customer i.e. from a single point to many points. The cost and the availability of storage space for unpredictable amounts of product returns are also important[b].

More importantly perhaps, there may be a limited quantity of returned product or 'core'[c], partly because there may be insufficient incentives for the user to return an item. We can explore this further.

When a product reaches the end of its useful life, from the customer perspective its utility value is zero. It may even be negative since there may be associated disposal costs. As King & Burgess (2005) point out, whilst the utility value of the product may be zero, the failure or wear in one component of the product may not be matched by failure or wear in others. However the customer may be unaware of this, and as a result the product may be disposed of for recycling or landfill.

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[a] The no–regrets potential in respect of energy efficiency is the opportunity to make cost savings from the implementation of energy savings equipment etc which are not taken up by business.

[b] King & Burgess 2005

[c] Slowinski 1998

One approach employed by OEMs/FAs to overcome this problem is to incentivise the customer to return the item. Examples of this include using 'deposits' to provide the customer with a monetary incentive to return the product, or developing an overall service architecture which depends for fulfilment on the return of the product e.g. trade-ins for new products or service delivery triggered by a return. A good example of the latter is employed by Kodak, when a disposable camera is handed in so that films are processed. Some OEMs/FAs use their corporate memory e.g. a record of the historical maintenance schedules to determine when remanufacturing should take place.

The third party remanufacturer will be at a disadvantage since it cannot control the design of the product or the way in which the product delivers service to the user/customer.

4.2 Sorting and disassembly

A significant amount of information has to become available before a product is remanufactured. The costs of gathering this information can be high relative to each product that is ultimately remanufactured because the process of disassembly, cleaning and inspection may ultimately not lead to remanufacturing. Walls (2006) identified that transaction costs are high in relation to recycling markets because the degree of recyclability/contamination may be difficult to detect in advance of the transaction taking place. Therefore where the market organises the collection, recovery and disassembly processes (e.g. for automotive parts), it may not know ex ante (at the point of disposal/purchase) whether it is possible to remanufacture the product[a]. In addition, further along the process, it may be difficult to identify remanufacturable components[b] because of their design, their sometimes poor condition and the fact that manufacture takes place overseas and technical knowledge is not widely available in the 'home' market where disposal take place.

Remanufacturing markets for recovered products are therefore unlikely to work perfectly because ex ante prices cannot be set which will reflect the costs of collection, transport and sorting. This introduces a significant degree of uncertainty and risk, with the consequence that:

- There may be insufficient investment in the collection infrastructure required to ensure a reliable supply of quality core, which is key to planning remanufacturing activity.
- Prices of returned products may not reflect underlying values, thereby leading to undersupply in the market.

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[a] Parlikad et al 2003

[b] King & Burgess 2005

OEMs/FAs may be able to leverage their role as the designer to design for disassembly, or design in 'signals' (in their broadest sense) that only they can decode, which communicate the state of the assembly of underlying components or products (RFID chips could be an example). This may however lead to a risk that third party remanufacturers can also 'decode' these signals, particularly where the product technical knowledge may represent part of the unique value of the OEM/FA. In these cases OEMs may seek to 'lock up' their proprietary knowledge and in effect create technological externalities[a] for third party remanufacturers which:

- Make the product more difficult to disassemble and remanufacture.
- Reduce the price so it is more competitive with remanufactured products.
- Create value in the brand that is difficult to imitate.

4.3 Market demand

The third information / transaction problem occurs at the decision to purchase the remanufactured product and therefore impacts on the level of market demand. Where customer behaviour has been studied in relation to remanufactured products[b], the results indicate that customers generally value remanufactured products lower than new ones.

Research point: Research further into customer perceptions of remanufactured products compared to new products in terms of quality etc. and how this impacts on the decision to purchase.

This does not appear to be a well-researched area, but we can suppose that purchasers consider that the utility of the product may be impaired. This limitation may be both in terms of product longevity and in the way the remanufactured products interact with others in a product 'system'.

This exposes two further risks. Firstly, the user could be 'locked in' to past technological innovation. An example would be tyres, where aspect ratios have got smaller or exhausts where specifications have been tightened[c]. Therefore the remanufactured product may not perform as well as the latest market offerings in terms of efficiency or effectiveness in use. Secondly, technological change may

[a] Occurs when the production function of one agent enters another agent's production or utility function without the latter being compensated

[b] Debo et al 2005

[c] Seitz, BRASS

also mean that the network of other system components has changed and therefore different functionality is required which can only be supplied by newer products.

Therefore any potential cost savings may vanish in respect of a remanufactured product if the product does not fulfil the role assigned to it.

Example: Aerial Lift Trucks

Traditionally refurbishment took place because of price advantages. But a changing system network of taller structures, bigger transformers and bigger poles meant that aerial lifts needed to be larger. This has meant purchasing new larger derricks and other field equipment rather than using remanufactured / refurbished trucks. But in this example, changes in design which meant fewer moving parts and greater labour productivity were an equally strong factor in the shift to purchasing new (Maxwell 2004).

So the purchaser of a remanufactured product is presented with a series of challenging risks which are heavily information-dependant (such as: how do I know that the remanufactured component will provide the required performance? how can I test this?) This may be exacerbated by the fact that the seller is likely to be a market intermediary i.e. not the remanufacturer. In these cases the transaction costs associated with procurement may actually be higher than the purchase price, and this may help to explain why any apparent price savings vis a vis a new product are not taken up.

The remanufacturing OEM/FA may be able to overcome some of these transactional cost problems by offering remanufactured products with warranties or service contracts similar to new (Sun Systems, Caterpillar) and use their reputation and brand image linked to these warranties to assist in this. However a remanufactured product may in fact be a ‘confidence’ good, where the qualities can never be fully evaluated by a customer i.e. the information deficiency may be so great that market solutions such as building up brand etc. may not work[a].

Research point: Investigate the key factors that influence the procurement decision making process in choosing remanufactured products.

From the above discussion, we note that OEMs/FAs can overcome some of the transactional problems by modifying and developing a service offering based on the product, but this is not widely employed. In the fragmented structure of globalised supply chains, where there is distributed knowledge and few vertically integrated firms, policy instruments may need to be developed that overcome these barriers, in particular to encourage both models of remanufacturing i.e. both OEM and independent third party remanufacturing.

[a] Ostertag 2001

5 Context for the Development of Environmental Policy Measures

In developing policy instruments, we should take into account the following key inter-relationships:

- The **existing policy regime:** the interaction with existing regulations and policy instruments, in particular recycling policies.
- **Transferable experience:** the experience to date in other models and whether this is transferable.
- The **social cost** of the implementation and operation of the policies compared to the social benefits.

5.1 The existing policy regime

Current public policy interventions accept that firms face inadequate incentives to internalise the environmental impacts of their production choices[a]. To date there have been two types of policy approaches employed:

- Policy measures to directly internalise the cost of waste related expenditures e.g. landfill tax, subsidies for waste processing facilities.
- The removal of policy failures in substitute primary material markets e.g. inappropriate product and material standards and subsidies for virgin materials.

[a] OECD 2007

However whilst these measures have increased recycling rates[a] they have not caused an equivalent increase in remanufacturing.

One reason maybe that there continue to be policy failures with regards to remanufactured goods in terms of product standards which restrict remanufactured goods as substitutes even if they are 'as good as new'. These may be health and safety or hygiene related, hence the balance between environmental protection and public health may not have been properly reflected. We should ensure that these standards should only be targeted at the product performance not constituents.

Research point: Investigate whether H&S- and health-related regulations discriminate against remanufactured products and, where they do, develop outcome-led specifications.

Another reason may be that existing policy instruments have been promoting one form of material recovery (materials recycling) and this may conflict with increased remanufacturing. There is evidence that for example in dealing with demolition waste in the UK, the amount of recycling has increased while the amount of reclamation for re-use or remanufacturing has declined[b]. Certainly specific incentives (such as financial subsidies for recycling plants) would seem to favour recycling. These policy instruments are in effect compensating for the costs of collection, sorting and disassembly of products which the market cannot bear i.e. the price of recycled materials is too high relative to virgin materials because it incorporates these costs.

However recycling is not the policy objective itself but a means to the overall policy objectives identified previously. In particular it is directed at reducing waste tonnage being disposed of to landfill. It is accepted that recycling is not always the most appropriate route to achieve a reduction in CO_2 emissions and energy conservation in all cases. Where it undermines activities that may be more environmentally and carbon beneficial, such as remanufacturing, then the emphasis on recycling could be regarded as a policy failure.

We can see this happening with respect to the relatively sophisticated recycling collection and reprocessing infrastructure which is now in place. It is not incentivised to collect end of life products for remanufacturing (or re-use). This may not only mean that products are directed into recycling processing when they should be remanufactured but it may also act to prevent the development of alternative collection and processing infrastructures to support remanufacturing (re-use, repair and refurbishment activities).

Research point: Investigate how alternative collection and processing infrastructures can be integrated with or developed alongside recycling infrastructures, and the extent to which public policy support is required.

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[a] OECD 2006

[b] BRE 2006

5.2 Transferable experience

Current extended producer responsibility (EPR) legislation is aimed at delivering sustainable development by passing back the costs of end of life management to producers, implementing the 'polluter pays' principle. OECD states that "The polluter in EPR is the agent who is able to reduce the social costs generated by the product chain; in other words, it is the agent who is capable of playing a decisive role in controlling the product chain."[a]

A key objective of EPR is a reduction in the social costs of waste and waste management; however the main focus to date has been on household waste and increasing recycling rates.

In the UK the most recent and prominent forms of producer responsibility legislation have concerned packaging waste, end of life vehicles (ELVs), and waste electrical and electronic equipment (WEEE).

The concept of EPR would appear to facilitate remanufacturing or recycling equally, because it transmits incentives for waste reducing innovations at the product design stage (article 8.2 of WEEE Directive). These changes should contribute to reducing the cost of recycling[b] and also remanufacturing. Indeed there has been an expressed hope in some literature[c] that WEEE legislation would lead to a greater interest in remanufacturing, but this does not seem to have happened. Tojo (2001) has indicated that anticipation of the regulatory requirements posed by EPR law led to several Japanese EEE manufacturers making material substitutions to increase the recyclability of their products and adopting modular designs to promote component re-use. Toffel (2004) explicitly states that take-back laws "encourage manufacturers to …remanufacture". However, it is unclear that, following implementation, financial incentives have been transmitted or have resulted in design changes that have benefitted remanufacturing activities[d].

There are a number of possible reasons why this may not have happened:

- **Prices are increased.** The producer can pass the financial cost of compliance with EPR legislation onto the customer through higher prices where the price elasticity of demand is low.
- **Recycling is the focus.** OECD research into EPR programmes across Europe indicates that the implementation of EPR policy instruments has been designed to increase recycling[e]. As a result, collection infrastructures have tended to be based on existing recycling collection systems. As we have noted previously, the careful collection of products for remanufacturing in order to preserve their value – for

[a] Ueta 2004

[b] Tojo & Hansson 2003

[c] Burgess & King 2005

[d] Van Rossem et al 2006

[e] Smith 2005

example their shape - is not necessarily compatible with collection systems and processes which target materials recovery.

- **The implementation of EPR policy prevents financial incentives from being transmitted.** The way in which some EPR policy has been implemented (e.g. WEEE in the UK) means that the collective recovery programmes distribute the cost of collection according to market share and therefore there is no incentive for changing designs or materials selection that enable either greater recovery of materials or the recovery of products for remanufacturing. Any firm that develops a design that may reduce waste or waste management will only benefit all firms participating in the producer recovery organisation (PRO) including competitors and therefore in effect the design change becomes a public good. (This, incidentally, would also negatively impact on any innovation for recycling.) The reverse is also true, in that any increased recycling or remanufacturing costs are not borne solely by the responsible agent therefore potentially creating a downward negative spiral. A number of manufacturers have already noted this effect[a].

However there needs to be more ex post analysis of the impact of EPR in terms of changes in product design that facilitate dismantling etc, with which to evaluate the impact of these EPR programmes[b].

Research point: Investigate the impact of EPR programmes on product design changes that facilitate dismantling etc. Identify the key factors and determine whether these changes have then resulted in increased recycling or remanufacturing activity.

There is currently a review of the WEEE Directive underway. This may offer the opportunity to develop more targeted incentives that could promote remanufacturing by encouraging product design changes to aid disassembly etc.

5.3 Social costs

When we develop policy instruments, we need to ensure that sufficient social benefits are generated to outweigh the social costs involved. The OECD has set

[a] CECED 2008

[b] Smith 2005, Tojo and Hansson 2003

out seven criteria[a] for the development of useful, and hopefully successful, policy instruments:

- Environmental effectiveness: The environmental damage that can be prevented or mitigated. In remanufacturing terms this would primarily refer to the CO_2 emissions that would be saved compared to use of virgin or recycled materials.
- Economic efficiency: Cost effectiveness in achieving the given level of abatement using economic instruments as against command and control regulation.
- Administration and compliance costs: Minimising these as they absorb potentially productive resources.
- Revenues: Generation of or reductions in expenditures e.g. waste management reductions as well as net additional revenues from remanufacturers.
- Wider economic effects: Inflation, employment growth etc.
- Soft effects: Changes in attitudes and awareness of waste minimisation and carbon conservation amongst the business community and the public.
- Dynamic effects and innovation: Ensuring that innovation is promoted or at least not stifled. Economic instruments are therefore likely to be more effective than regulation.

The social benefit of a policy to promote remanufacturing might be calculated by taking into account:

- Savings in any publicly funded waste/recycling collection programmes or PROs under WEEE regulations because remanufacturing activity takes waste out of the system. This would need to include transport costs plus.
- Net reduced landfill costs (i.e. additional landfill cost saved as compared to recycling) plus.
- Reduced costs of virgin and/or recycled materials substituted.

[a] OECD 1997

These costs and benefits can largely be quantified using prices, but there will also be the external costs and benefits with which we are principally concerned (i.e. the valuations of marginal net external damage in terms of polluting emissions, disamenity to local residents etc). These will be difficult to calculate especially as the collection and transport of products at the end of their lives will cause pollution etc, as would the collection of waste and recyclates. In addition, the remanufacturing of products will use energy but generally less than the reprocessing of recyclates and their use in product manufacture.

Research point: Calculate the reduction in environmental damage across the whole life cycle of a product when it is remanufactured compared to being produced from recycled or virgin materials.

One of the issues, particularly relevant to the UK, is that the external social benefits may impact outside the UK, for example if the manufacturing plant is located in China whereas the remanufacturing operation takes place in the UK. Whilst this offers the opportunity for greater employment growth in the UK, which we may want to take as a social benefit, the net external benefit will mainly accrue to China. This would point to other social benefits being critical to identify.

Research point: Investigate the balance between potential global social benefits compared to UK social benefits for particular remanufactured product categories, and determine how UK social benefits can be maximised.

We also need to consider any negative innovation effects. We have already recognised that, by remanufacturing, we are preserving aspects or elements of the original design which may not be as functionally efficient as newer designs. Indeed there may in fact be environmental 'bads' resulting from remanufacturing because improvements in energy efficiency may offset the carbon benefits of replacing a product. It is important to recognise this interaction when we are developing policy because we need to consider the overarching policy objective which is to increase total resource efficiency i.e. resource per unit of use value.

Research point: Investigate further the relationship between the innovation and de-carbonisation policy objectives, in which sectors and product categories this conflict is most likely to occur, and those sectors where they can be mutually reinforcing.

6 Developing Policy Instruments

6.1 Policy objectives

In developing potential policy instruments, we need to keep in mind the overall policy goal which is *"no different than that for any other environmental policy – to maximise social welfare"*[a]. Therefore remanufacturing is not an end in itself. Specific policy objectives would be to:

- Prevent environmental 'bads.' Where the waste management costs of products, and their CO_2 and other environmental impacts, are a cost to society as a whole, whether through publicly funded infrastructures or other mitigation measures rather than users or producers, there is no incentive either for producers to design products with low end of life disposal costs or for users properly to dispose of these products.
- Increase the efficient use of natural resources. In the absence of pricing signals in respect of the use of virgin materials and energy (although this may be changing), there are no means to signal to producers the need to design and manufacture products in a resource efficient manner particularly in respect of conservation of carbon.

In this section, we look at the areas where intervention may be most effective in achieving the above policy objectives and the types of policy instruments that may be most suitable.

6.2 Areas of focus

Taking into account the above policy objectives and the barriers identified in the previous section, we believe the following areas for public policy interventions are worthy of attention:

[a] Walls 2004

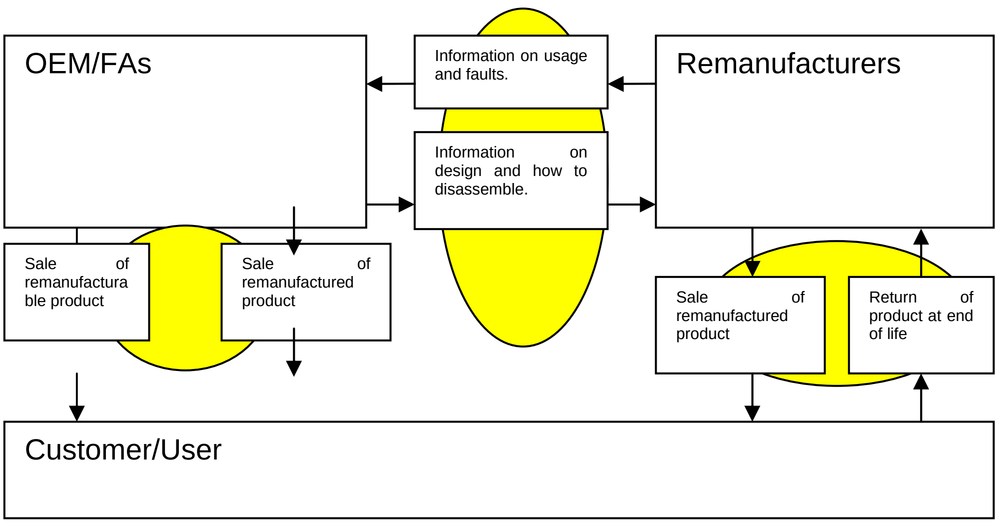
- Incentivisation of product return.
- Correction of information deficits or asymmetric information:
    - Improvement to the flow of information to purchasers so that purchaser confidence can be improved and customers decide to make purchases of remanufactured products
    - Customers buy remanufacturable products because they are aware the product will have value at end of its life
- The diffusion of technical knowledge and 'design for remanufacture' is encouraged which facilitates disassembly, sorting etc.
- Removal of policy failures, so that policy is 'blind' to the means by which the overall policy objectives are achieved.

But where should interventions be directed in order to initiate the change required? Is it possible to identify one agent - the polluter? The current economic system based on a globalised economy is characterised by complex supply chains in different geographies. In particular, where there has been significant vertical disintegration, the designer and the manufacturer may not be co-located. The WEEE legislation has identified the importer as the 'producer' if the manufacturer is located outside the EU. This is a good place to locate one point of intervention.

However, in respect of remanufacturing, there are at least two other parties involved: the remanufacturer and the user/customer. Taking into account the need to stimulate both supply and demand, all three parties need to be the subject of the policy interventions. There is no one co-ordinating agent, except perhaps where the OEM/FA is also the remanufacturer.

We can use a simplified model of remanufacturing, to highlight the possible points of intervention, highlighted in yellow (Figure 2 below):

Fig. 2: Points of intervention



6.3 Types of economic instruments

Economic instruments are regarded as a better type of policy instrument since they impose a cost or price on a negative outcome and therefore provide a continuous incentive to innovate. Examples might be subsidies, taxes, penalties etc. A key principle is that they should be set to change the behaviour of the relevant actors. They also have to be set at a sufficiently high level compared to the costs of alternative technologies or solutions or they may be ineffective[a]. Is this politically feasible? Kemp (2000) has indicated that during periods of technological uncertainty, the policy making process is prone to set taxes at a low level in order to reduce the burdens on existing industries.

Economic instruments may include subsidies paid for collecting core and remanufacturing it, or a tax on new products which is refunded when goods are remanufactured, or a rebate/credit on remanufactured or remanufacturable products.

The first question is: should the financial subsidy or tax depend on whether a product is (or is not) actually remanufactured, or on the product's potential to be remanufactured? After all, it is only in the former case that the social benefits are delivered. Since it is unlikely that governments will be able to determine ex ante the level of remanufacturability of a product for purposes of assigning a subsidy or tax to individual products, we would suggest that any financial incentive should be directed at the final remanufactured product.

Recommendation: Develop a model for financial incentives that focuses on the end result of remanufacturing activity: the final remanufactured product.

But which party should receive the subsidy? As we have noted above, the remanufacturing model is dependent on OEMs in two ways: firstly the availability of products (they must be manufactured and sold for first use) and secondly the availability of technical information to aid collection, disassembly, replacement etc. We have also previously noted that there is significant potential conflict in certain markets between OEMs/FAs and third party remanufacturers, which manifests itself in designs etc. that prevent disassembly for remanufacture (Section 4.2).

Mitra & Webster (2008) have undertaken work in this area that may be relevant. They modelled the effects of government subsidies as a means to promote remanufacturing activity. They looked at various rates of subsidy, the allocation of subsidies between OEMs and remanufacturers and investments to increase the rates of return. They came to two relevant conclusions:

[a] Mickwitz et al 2008

- That remanufacturing activity is generally higher, and the OEM's profit as well as the remanufacturer's profit are both likely to increase, when the manufacturer and the remanufacturer share the subsidy, even though they may be in competition.
- That remanufacturing activity is sensitive both to the rate of recovered products and the rate of subsidy, and that these are mutually dependent.

Previous work that Mitra & Webster undertook in respect of the interaction of product take-back laws and remanufacturing came to similar conclusions[a]. The key driver in this context was that the cost of disposal of a product was met by the OEM, but this cost could be partly offset by the sale of the end of life product to a remanufacturer. The OEM would therefore be incentivised because of a reduction in its disposal costs. The OEM's response was therefore to design products for disassembly or to release technical information that made them easier to disassemble etc.

The extent of such a response, if it takes place at all, is likely to depend on:

- The extent to which an OEM calculates that its share of the subsidy is sufficient to compensate for loss of current and future sales, and
- The implementation of an EPR scheme which ensures the cost of disposal of end of life products falls to be met by OEMs.

Indeed, as we have noted in earlier sections of this report, some OEMs may themselves embark on remanufacturing as a response.

In view of the above issues, it is likely such a financial subsidy will need to be set at a sufficiently high level to compensate for the risks to the OEM/FA and the costs to the remanufacturer. Possible reference benchmarks for the subsidy level could be:

- The equivalent costs of carbon saved, or
- The equivalent savings to the 'public purse' that are being obtained from not subsidising the waste collection/recycling system.

It will also be important to understand the incidence of these subsidies i.e. who will they actually benefit (and of course how will they be financed).

[a] Mitra & Webster 2007

We have already identified that customer behaviour is key in that it drives both the return flow of used products and the market demand for remanufactured products. Therefore we should contrive to ensure that part of any subsidy paid to remanufacturers in accordance with the amount of products remanufactured is used to pay customers to return products at end of life rather than subsidise the price of remanufactured goods. This could:

- Increase demand, since the customer would take that income into account when purchasing, thereby increasing the price differential between remanufacturable and other products. There would of course need to be some labelling framework to provide such information to the purchaser in the first place.
- Increase the supply of remanufacturable products, either because OEMs would recognise they had a value at end of life and would either collect core and sell it on to remanufacturers, or because they could be sold at a higher price if the customer then sold them onwards.
- Discourage other means of disposal including illegal disposal and recycling.

If financial incentives were directly targeted at the customer, positive pricing signals could be transmitted to remanufacturers and OEMs without the complication of establishing respective shares of any subsidy.

One area which has been suggested is the provision of a VAT rebate on remanufactured products at the point of sale. Such a rebate is feasible and allowed for under EU regulations[a] until 31.12.2010. An EU study[b] found that a permanent reduction of VAT on a particular product or service will usually lead to "an equivalent reduction in the price of that service". There is usually therefore full pass-through of any rebate. The study found that the extent of any pass-through is dependent on labour intensity and strength of competition. The higher the latter factor the greater the degree of pass-through. This is likely to be because price elasticities are correlated with labour intensity, and remanufacturing activity is usually highly labour intensive (collection, cleaning, disassembly etc).

As a result of the Copenhagen Economics study, the EU issued a communication (COM(380)2007) which provided a basic structure of tiered VAT reductions depending on policy objectives. It allowed an intermediate rate of between 10% and 12% which could be applied to goods that deserve preferential treatment because of their environmental and energy benefits. But how to select these?

Where the 'in use' phase may be important from a carbon perspective and we want innovation to increase efficiency, by subsidising remanufactured products

[a] EU Directive 2006/18 of 14 Feb2006

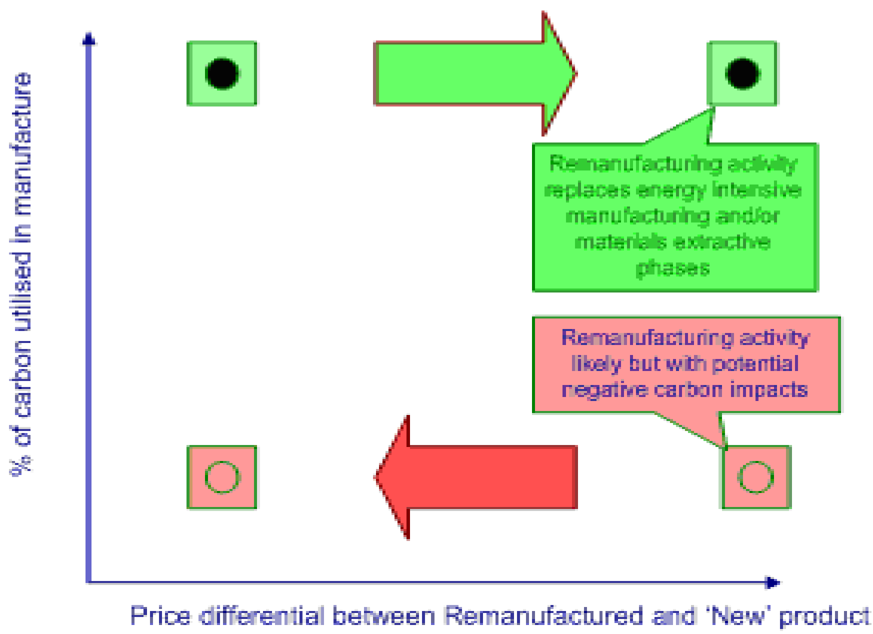
[b] Copenhagen Economics 2007

we may be discouraging innovation. There is some evidence of this negative innovation effect in recycling EPR programme[a]. This is an interesting effect of PROs or collective schemes in general.

Also, for some products it may be more environmentally beneficial to recycle or indeed incinerate. This would mean that the product categories to which a financial incentive would be applied would need to be carefully selected and are unlikely to be energy using products (EuPs).

Figure 2 below shows that it will be necessary carefully to select the product groups where remanufactured products should be incentivised so as to avoid incentivising remanufactured products where the carbon benefits of remanufacturing are likely to be low.

Fig. 3: Carbon benefit and remanufacturing potential



Recommendation: Determine which product categories/sectors are suitable for targeted policy interventions to incentivise/encourage remanufacturing activity.

In addition, there may be a problem maintaining budget neutrality. Within the context of an overall tax policy, 'bad' environmental choices/activities could be taxed at a higher rate or there could be a reduction in recycling subsidies. Neither of these options is likely to be politically acceptable. However, because

[a] OECD 2005

of the labour intensity of operations, the positive employment and business response to a financial incentive for remanufactured products may generate additional turnover and employment (and therefore taxes), and although this may be offset by some loss of sales of OEM/FA products and consequent employment, these negative effects are more likely to occur overseas rather than in the UK.

We should also recognise that underpinning the use of any financial incentives is the assumption that pricing or cost signals will change behaviour. Work in other sectors (e.g. energy efficiency) indicates that non-price policy measures are also important in overcoming barriers[a]. The next section looks at the need for greater information flow across organisational boundaries to facilitate increased manufacturing activity.

6.4 Information provision

A study by Tojo (2001) indicated that design changes upstream only occur when knowledge is also passed along. Examples from the recycling arena indicate ways that this can be facilitated:

- In Japan, home appliance manufacturers have encouraged designers to meet with recyclers to understand what makes it easier to disassemble.
- In Sweden, car manufacturers have been communicating with recyclers to better design for end of life management.

Can we encourage product technical knowledge diffusion to facilitate disassembly, cleaning and inspection without infringing the OEM's IPR? This is a classic economic welfare issue emphasized in the law and economics literature i.e. that IPRs tend to affect both innovation creation (positively) and innovation access (negatively). We want to increase diffusion to raise the performance of the industry sector but at the same time we need to incentivise the developer of the new technology, design etc. to incur the development costs required.

The automotive sector is interesting because there seems to be a significant amount of remanufacturing taking place. How is this happening? And has IPR been contravened?

[a] IPCC 2001

Example: The case of the Automotive Industry

It is probably because open standards and modular design approaches are prevalent in the automotive sector and that there is an effective supply chain comprising dismantlers, remanufacturers etc, that governments have been able to facilitate greater exchange of technical information as part of the implementation of EPR schemes. For example the ELV Directive requires manufacturers to mark materials using a standard nomenclature and distribute technical information to facilitate the dismantling of their cars. In Sweden, car manufacturers have been encouraged to collaborate with some dismantlers in an effort to enhance the disassembly of their cars (Tojo 2001).

If we consider products as unique combinations of elements, both the materials and other products, we can appreciate that they lie within in an 'architecture', a framework which connects the parts/components or other products and that maximises profitability. A car is a good example of a product architecture, comprising as it does many other products or components. As the automotive market for cars has matured, these components have tended to become modular designs i.e. commoditised and available to other final assemblers. However, this is not uniformly the case across the automotive industry. We note the prevalence of on-board diagnostic computers in newer models and that this is an area where OEMs/FAs are retaining control, because their IPR is at stake and this has obvious impacts on the third party remanufacturing sector. We also note that there is literature[a] which suggests that modular design approaches actually protect proprietary knowledge because information can be hidden and access is controlled through interfacing rules. In this way modular design and open standards at a system level may offer a resolution of the potential conflict between retention of IPR and diffusion of technical knowledge.

Research point: Investigation of the interaction of modularity, open standards and remanufacturing potential.

The general point is that modularisation has led to the development of open standards enabling components to be differently used in combination. We can see this in other sectors where makers of complex systems or product architectures are increasingly delegating responsibility in both design and manufacturing to suppliers[b]. This growth in modularity not only allows for the mixing and matching of components but also potentially the greater re-useability of components and the upgradeability of products[c].

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[a] Baldwin & Clark 2006

[b] Mikkola 2000

[c] Garud et al 2003

King & Burgess (2005) have specifically examined how platform design, a variant of modular design of multi life components around which single life components would be used for product differentiation, can be encouraged. This would enable both final disassembly and obsolescence to be accommodated and therefore open up opportunities for remanufacturing activity.

Research point: Investigate how modular design can be promoted in higher and further education to facilitate remanufacturing and re-use of product components.

Modular design also has an organisational effect, which is of interest. It tends to lead to the vertical disintegration of supply chains between final assemblers and component manufacturers and subassembly manufacturers. In other words, the communication of knowledge and specifications and the building organisational learning has to be mediated across the boundaries of the firm. The co-operation and co-ordination of various different groups of practitioners, each holding a different body of formal knowledge, is therefore essential for the effective working of the supply chain. How is this overcome? And are there lessons that could be learned which are transferable to the remanufacturer's relation with the OEM/FA?

Research point: Investigate how technical information exchange can be transferred across organisational boundaries to facilitate design for disassembly and recovery and the remanufacturing of product components.

A stable pattern of connections has to be organised so that various forms of technological knowledge can be aggregated and utilised in the design and production of components[a]. One way this is achieved is through the co-location of automotive suppliers with final assemblers. Krikke et al (1999) suggest that this may also be an approach to facilitate information exchange between dismantlers, and OEMs and thereby facilitate a closed loop supply chain including potentially remanufacturing. This is similar to the 'Kalundborg' approach i.e. the establishment of eco-business parks where the waste of one organisation becomes the resource input of another.

Research point: Investigate the feasibility of 'transaction-free' spaces available to all interested parties - these may be funded collection entities.

[a] Araujo 2006

We have also identified an information barrier associated with the purchasing of a remanufactured product. Because information is a public good and will be expected to be undersupplied by the market (i.e. a market failure) labelling etc. may be justified to identify the quality and performance of the remanufactured product. This labelling may need to be underpinned by standards. As we identified, remanufactured goods tend to be confidence goods and therefore, in the presence of asymmetric information, will be under demanded i.e. remanufacturers may have more information about the quality of their products than do customers.

These issues can be addressed through:

- Certification schemes.
- Testing facilities.

Research point: Investigate how certification schemes might operate, whether voluntary or mandatory, and the standards that should underpin them.

It will be important that the standards set are balanced between the need to protect purchasers whilst at the same time encouraging remanufacturing activity. A particular danger is that standards may be set unduly high under the influence of lobbying from OEMs and FAs.

This issue of labelling and certification is also connected to the implementation of product take-back legislation, which we consider in the next section.

6.5 Product take-back (EPR)

We have identified that the operation of current product take back or EPR schemes favour recycling (materials recovery) rather than remanufacturing. We also recognise that the current WEEE Directive and this year's review will lead to expansion of the scheme to include stationary electrical equipment and aims to strengthen individual rather than collective EPR schemes. In particular the re-use of products or their refurbishment is explicitly targeted. This should offer an opportunity to support encouragement of remanufacturing in three areas:

Firstly, in increasing market demand for remanufactured products by providing independent quality assurances to customers. This is reflected in some of the OEM responses to consultation on the review, where the role of remanufacturing / refurbishment is accepted but with caveats. OEMs argue that in order to create a level playing field when competing with new products, these refurbished / remanufactured / repaired products should be rebranded so that they are not associated with original brands. The European Committee of Domestic

Equipment Manufacturers argues that these products should also be energy labelled in the same way new products are[a]. This seems a sensible approach.

Additionally, CECED argue that because older products may contain hazardous materials since banned or unsafe in use, they may not meet latest safety regulations etc and that therefore re-users / refurbishers / remanufacturers should be licensed. Again, a licensing system would provide quality assurance to customers.

Secondly, in better incentivising innovations in product design that would facilitate disassembly etc. the review aims to strengthen individual producer responsibility.

Recommendation: Introduce provisions to publish technical information as part of the current revision of the WEEE Directive.

One of the ways this could be done is to develop alternative models to the current collective recovery schemes, which as we have noted previously do not provide direct financial incentives to OEMs/FAs. We note that in a number of states in the USA (e.g. Maine) there are return share arrangements in place (since 2006) whereby the costs of collection and sorting are allocated to each manufacturer according to the direct costs of recovery, sorting and disassembly. Such an approach offers a way to make IPR compatible with collective recovery.

It is suggested that one reason that collective schemes have been adopted to date is that they are more efficient as they benefit from scale economies. A ‘return share’ arrangement may therefore add to the overall cost of the scheme. However, there has been no direct research into whether this is a more efficient in terms of overall costs e.g. the greater efficiencies of larger scale collection and recovery may outweigh the savings that any individual firm could deliver through innovation in product design etc.

The key to a cost effective operation is the timing of the product identification process[b]. For example:

- at the point when the end-user discards products
- at product aggregation points and
- at recovery facilities.

The later in the process, identification takes place, the less opportunity for direct costs to be passed to OEMs/FAs.

[a] CECED 2007

[b] Van Rossem et al 2006

Research point: Undertake an economic analysis of the 'return share' arrangement in comparison with collective recovery arrangements and investigate the impacts, if any, on the product design process.

Thirdly, by removing the emphasis on recycling. The existing collection infrastructures are primarily aimed at household waste arisings and geared to materials recovery. This incumbent position makes it difficult for new producer schemes to be set up[a] because of the scale economies present. So how can alternative collection infrastructures which can supply carefully collected products for re-use be encouraged? Policy interventions may be possible in two areas:

- In making it easier for third party remanufacturers and other re-use organisations to be come authorised collectors within take back schemes.
- By setting targets for re-use to include remanufacturing.

We know that targets for re-use are being considered as part of the current review of the WEEE Directive. This should provide an opportunity to develop appropriate incentives for remanufacturing, providing these are based on an evidence base which has correctly identified those sectors/products where remanufacturing and re-use provide additional social/environmental benefits.

6.6 Removing policy failures

Remanufacturing is not an end in itself. We see it as one of the ways through which key overarching environmental policy objectives can be achieved i.e. a reduction in total waste and increased resource efficiency particularly in the use of energy. Other routes include recycling (defined as the recovery of disassembled materials), landfill or incineration. However, we have identified that the emphasis on coupling recycling targets with EPR legislation has favoured a particular route for used goods processing which may in fact be leading to a non-optimal result in relation to carbon conservation i.e. discrimination against re-use and remanufacturing. We have also seen this in public procurement policies which emphasise a certain percentage of recycled content in products.

[a] Tojo & Hansson 2003

To rectify this will either mean removing these targets or creating equivalent targets for re-use including remanufacturing. We noted previously that this is being actively considered as part of the current review of the WEEE Directive.

We would therefore seek to review existing environmental policy instruments to ensure that:

- A holistic product life cycle approach is encouraged.
- Common criteria are applied in order to determine the correct disposal route is encouraged in respect of each particular product category.

We think that the extent to which GHG emissions are reduced (i.e. carbon conservation) would be the most appropriate measure and would ensure in the longer term that, where appropriate, recycling is not prioritised over remanufacture.

Recommendation: Review existing policy instruments to ensure that overarching policy goals are being supported using common criteria e.g. carbon reduction.

7 Conclusions

The level of remanufacturing is not optimal. There are a number of barriers to its further adoption and these are principally transactional concerning the availability of information which give rise to considerable additional costs.

We have noted that remanufacturing may not always be the most appropriate disposal route for a product after the end of its first life, if newer designs provide functionalities that have both economic and environmental social benefits. To this extent there can be negative innovation effects.

Some OEMs, particularly those in market dominant positions, are able to integrate / co-ordinate activities throughout the product lifecycle and therefore recover and remanufacture products.

Where the market organises remanufacturing activities, the transaction costs associated with collecting, cleaning and disassembling products at end of the first life are sometimes considerable. This is potentially an area where the market does not operate in an optimal fashion and therefore public policy intervention is justified.

Current policies, particularly the implementation of EPR, are favouring recycling rather than other alternative used goods processing routes. This could be considered a policy failure which needs to be corrected.

We have identified a number of areas where policy intervention could take place:

- The removal of policy barriers to create an equal playing field in respect of the different means by which overall policy objectives could be achieved.
- Improvements in the flow of information between OEMs, customers and remanufacturers so that purchaser confidence can be improved.

In terms of ensuring that an integrated policy is developed which is 'blind' to the various different disposal routes but reflects overall policy objectives, we concluded that carbon criteria would be useful as focus would then be on incentivising the most effective disposal route in terms of minimisation of CO_2 emissions while simultaneously supporting the UK Government's current international climate change commitments. We also need to be aware that the established recycling infrastructures and industry already in place may present an obstacle to increased remanufacturing activity.

We felt that economic instruments could potentially be utilised, providing they were based on robust evidence of products/product groups where remanufacturing offered carbon benefits over and above alternative disposal options including recycling. At this point in time, work has barely started on the development of such an evidence base.

8 Further Research Requirements and Recommendations

8.1 Research points

Research point: Investigate how Xerox and Caterpillar undertook remanufacturing activities as a response to external competition in order to understand the key factors that enabled the adoption of a business model that included remanufacturing.

Research point: Investigate the relative proportions of remanufacturing activity in turnover terms undertaken by OEM rather than third party remanufacturers.

Research point: Research further into customer perceptions of remanufactured products in terms of quality etc. as compared to new products and how this impacts on the decision to purchase.

Research point: Investigate the key factors that influence the procurement decision making process in choosing remanufactured products.

Research point: Investigate whether H&S and health-related regulations discriminate against remanufactured products and where they do develop outcome led specifications.

Research point: Investigate how alternative collection and processing infrastructures that facilitate remanufacturing can be integrated with or developed alongside recycling infrastructures, and the extent to which public policy support is required.

Research point: Investigate the impact of EPR programmes on product design changes that facilitate dismantling etc. Identify the key factors and determine whether these changes have then resulted in increased recycling or remanufacturing activity.

Research point: Calculate the reduction in environmental damage across the whole life cycle of a product when it is remanufactured, as against being produced from recycled or virgin materials.

Research point: Investigate the balance between potential global social benefits compared to UK social benefits for particular remanufactured product categories, and determine how UK social benefits can be maximised.

Research point: Investigate further the relationship between the innovation and de-carbonisation policy objectives, in which sectors and product categories this conflict is most likely to occur, and those sectors where they can be mutually reinforcing.

Research point: Investigate the interaction of modularity, open standards and remanufacturing potential.

Research point: Investigate how modular design can be promoted in higher and further education to facilitate remanufacturing and re-use of product components.

Research point: Investigate how technical information exchange can be transferred across organisational boundaries to facilitate design for disassembly and recovery and the remanufacturing of product components.

Research point: Investigate the feasibility of transaction "free" spaces available to all interested parties - these may be funded collection entities.

Research point: Investigate how certification schemes for remanufacturing/re-use might operate, whether voluntary or mandatory, and the standards that should underpin them.

Research point: Undertake an economic analysis of the 'return share' arrangement in comparison with collective recovery arrangements and investigate the impacts, if any, on the product design process.

8.2 Recommendations

1: Maintain an annual record of total remanufacturing activity in the UK by sector in turnover terms. This would be a useful measure of the success or otherwise of policy interventions to encourage remanufacturing activity.

2: Develop a model for financial incentives that focuses on the end result of remanufacturing activity – the final remanufactured product.

3: Determine which product categories/sectors are suitable for targeted policy interventions to incentivise/encourage remanufacturing activity.

4: Introduce provisions to publish technical information as part of the current revision of the WEEE Directive.

5: Review existing policy instruments to ensure that overarching policy goals are being supported using common criteria e.g. carbon reduction.

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