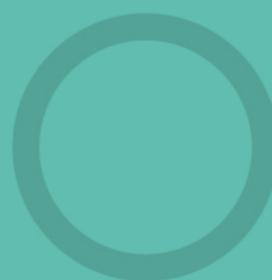




# Circular Economy Evidence Building Programme Remanufacturing Study Summary report

March 2015



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## 1 Introduction

This document summarises the findings of an investigation into the characteristics of the Scottish remanufacturing industry, including analysis of the key barriers, enablers and opportunities for the industry and provides recommendations for supporting the growth of the industry. This document is supported by a detailed report, which provides the in-depth analysis and background used to produce this summary.

## 2 Background, scope and prior research

### 2.1 Remanufacturing and the circular economy

Circular economy activities cover the whole length of the supply chain, starting with product design, through part and product manufacture, then product use and, lastly, activities at the end of a product's service life. In a circular economy, the maximum value from product is derived by retaining as much of the embedded material, labour, energy and capital as possible both throughout the supply chain and at the end of each service life.

Remanufacturing is a key strategy within the circular economy. It is typically applied to complex manufactured products that possess significant embedded material, energy and labour resources, most of the value of which can be recovered by suitable remediation techniques. Often, remanufacturers take the opportunity to upgrade the products from old to current performance standards of energy efficiency or productivity. This is one way that they can be differentiated from products which have simply been repaired or undergone other end-of-life treatments.

### 2.2 Definition of 'remanufacturing'

Unlike 'recycling', 'remanufacturing' does not have a universally accepted or recognised definition. This is partly due to its use across a wide number of sectors, where alternative phrases are used that could be interpreted as remanufacturing. Another reason is that there is little European or nationally defined legislation targeting remanufacturing. There have been several attempts to standardise the definition. Probably most relevant to Scottish remanufacturing is the BSI Standard BS 8887-2:2009 that defines a range of end-of-life options for products including remanufacturing. Within this document, remanufacturing is defined as to:

**Return a used product to at least its original performance with a warranty that is equivalent or better than that of the newly manufactured product.**

*NOTE 1 From a customer viewpoint, the remanufactured product can be considered to be the same as the new product.*

*NOTE 2 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; and*

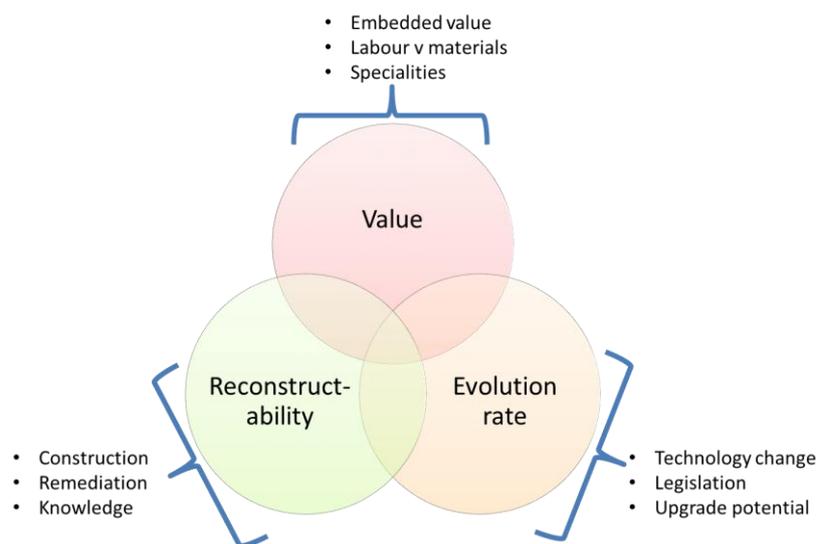
— *any subsequent warranty is generally at least equal to that of new product.*

*NOTE 3 This assumes that remanufacture applies to like-for-like products.*

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### 2.2.1 Remanufacturing product characteristics

It is important to note that remanufacturing is only applicable to set of products with a key set of characteristics. As a result, only certain product groups are suitable for remanufacturing. Furthermore, certain makes or models of products are suitable for remanufacturing within specific product groups. These characteristics were discussed at length by Parker in 2004<sup>1</sup> and are summarised below.



**Figure 1 Feasible operating space for remanufacturers**

Figure 1 is a simple graphical representation of product characteristics that can determine the remanufacturability of a product.

**Value** implies that more expensive items will naturally lend themselves to remanufacture because of the invested time and resource to achieve a like-new performance.

**Re-constructability:** Products which are more easily disassembled and reconstructed are more suited to remanufacture.

**Evolution Rate:** Primarily this relates to the change in functionality or capability of goods, features, size, weight, power, economy, emissions and longevity.

### 2.2.2 Remanufacturing company characteristics

There are three broad categories of remanufacturers:

- **Original Equipment Manufacturers (OEMs):** Involved in the design, manufacture, sale and remanufacture of a product. They usually have access to all the technical drawings and have the ability to include design upgrades to encourage remanufacturing.
- **Contracted remanufacturers:** Perform remanufacturing on behalf of an OEM. They will usually have access to most of the technical specifications of the product but usually have limited access to designers and have some restrictions on how they operate commercially.
- **Independent remanufacturers:** Usually directly compete with OEMs with their product. They usually have little formal relationship with the OEMs and have garnered technical information through reverse engineering and understanding of the product.

<sup>1</sup> Resource Recovery Forum, Remanufacturing in the UK: a significant contributor to sustainable development? 2004

## 2.3 Scope of the research

This research maps the size of the remanufacturing industry in Scotland across key sectors. It is important to recognise that different terminology has built up in different industries that could be considered remanufacturing. For example, aerospace and marine use 'overhaul' and 'refit' to indicate remanufacturing activities and medical imaging equipment refers to 'remanufactured' product as 'refurbished'. Added to these clear-cut examples where remanufacturing has a different terminology, less formal use of 'refurbishment' and 'reconditioning' make identification of the appropriate business activities difficult. This is particularly acute in small businesses where the terms 'refurbishment' and 'reconditioning' are more prevalent.

This report captures a variety of end-of-life practices that extend the life of a product including both refurbishment and reconditioning, as well as overhaul and refit. The project does not focus on straight re-use (where no manufacturing effort has been applied to improve the performance of the product) or repair (where a specific and defined fault is fixed) activities.

## 2.4 International and European market size

There are no official trade data on the size of remanufacturing nationally or internationally. There are, however, two reports that detail remanufacturing on a national level that will be used to scale for Europe and the rest of the world. The UK report: *Remanufacturing in the UK, A snapshot of the remanufacturing industry in the UK* by the CRR in 2009 and the United States International Trade Commission's: *Remanufactured Goods, An Overview of the U.S. and Global Industries, Markets, and Trade in 2012* use similar methodologies to understand the size of their respective remanufacturing markets. This involved market segmentation and then engagement with stakeholders to understand the remanufacturing landscape. Based on observations from market practitioners and other sources, the market size is determined. This methodology is similar to that employed within this project.

European data were extrapolated from the UK data using GDP as a scaling factor (GDP for the EU is seven times that of the UK). Rest of World data were estimated based on comments in the US<sup>2</sup> which claimed that the 'bulk' of remanufacturing activity was contained within the USA and EU. It was estimated that the rest of the world made up 20 % of the combined EU/US remanufacturing output. These findings are summarised in Table 1.

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<sup>2</sup> International Trade Commission Investigation No. 332-525 USITC Publication 4356 October 2012 Remanufactured Goods: An Overview of the U.S. and Global Industries, Markets, and Trade

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Sector	US <sup>1</sup>	EU <sup>2</sup>	ROW <sup>3</sup>	UK <sup>4</sup>	Total
Aerospace	13,000	22,000	7,000	3,200	42,000
HDOR Equipment <sup>6</sup>	7,800	5,500	2,700	790	16,000
Motor vehicle parts	6,200	4,500	2,100	650	13,000
Machinery	5,800	780	1,300	110	7,900
IT products <sup>5</sup>	2,700	6,900	1,900	1,000	12,000
Medical devices	1,500	760	450	110	2,700
Re-treaded tyres	1,400	440	360	64	2,200
Other <sup>7</sup>	4,600	6,700	2,300	960	14,000
<b>Total</b>	<b>43,000</b>	<b>48,000</b>	<b>18,000</b>	<b>6,900</b>	<b>110,000</b>

**Table 1 Remanufacturing activity (Turnover, millions US\$) (2 significant figures)**

1 based on United States International Trade Commission Investigation No. 332-525 USITC Publication 4356 October 2012 Remanufactured Goods: An Overview of the U.S. and Global Industries, Markets, and Trade

2 Scaled using GDP ratios between the UK and EU27

3 Calculated as 20 % of the sum of EU and US remanufacturing activity

4 Modified data set from Remanufacturing in the UK: A snapshot of the remanufacturing industry in the UK in 2009, CRR.

5 including printer cartridges

6 Heavy-Duty Off-Road including construction, lifting and earth moving equipment

7 Includes catering, office equipment, pumps and compressors, rail, textiles and white goods.

Using this analysis, aerospace is by far the largest sector in terms of remanufacturing. Also, the USA is the largest single remanufacturing economy, but the EU's industry is of a comparable size.

### 3 Summary of the Scottish remanufacturing industry

#### 3.1 Sector identification

Remanufacturing cuts-across many manufacturing sectors. However, experience has shown that Standard Industry Classification codes alone are a poor method for providing meaningful division of the industry into relevant sectors. Remanufacturing occurs at the product level, and a 'bottom-up' approach looking at products would be more appropriate. Unfortunately there are no appropriately detailed lists of products from which an investigation into remanufacturing could be performed. As a result, a hybrid system was employed using industry classification as the starting point but also recognising that certain product groups (that would not necessarily categorise easily within SIC) were also important.

## 3.2 Market size

Fourteen key remanufacturing sectors were identified as likely to have the largest significance to the Scottish economy. For each sector, contacts were identified through Zero Waste Scotland, Scottish Enterprise, Oakdene Hollins and its subcontractors and internet/web searching. A series of directed conversations were then held to gain comment, opinion and fact on the size of the remanufacturing industry, barriers and potential mitigations to encourage remanufacturing.

Product group	Turnover UK <sup>1</sup> (£ m)	Turnover Scotland (£ m)	Scotland as % of UK	Employment (no of persons)	Environmental impacts (tCO <sub>2</sub> e)	Growth potential
Aerospace	2,000	670	33	3,400	17,000	Medium
Energy	N/A	300	N/A	10,000	6,600	High
Automotive	410	35	9	900	4,100	High
Rail industry	80 <sup>2</sup>	35	3 <sup>3</sup>	160	4,100	Medium
Marine industry	N/A	34	N/A	650	-	Low
ICT and mobile electronics	75	19	25	700	630	High
Pumps, fans and compressors	200	30	15	360	3,500	Low
Ink and toner cartridges	440	6.6	3	30	88	Low
Medical equipment	14	0	0	N/A	N/A	High
Tyre re-treading	110	3.5	3	50	-	Medium
White goods	26	1.1	4	70	1400	Medium
Catering and food industry	11	1.0	9	350	210	Low
Furniture/office furniture	21	0.25	1	20	100	Medium
Vending machines	N/A	0	0	0	0	Low
<b>Total</b>	<b>4,400</b>	<b>1,100</b>	<b>25</b>	<b>16,700</b>	<b>37,700</b>	
<b>Total excluding aerospace</b>	<b>2,400</b>	<b>470</b>	<b>20</b>	<b>13,300</b>	<b>20,700</b>	

**Table 2 A summary of the impact of key remanufacturing sectors on the Scottish economy.**

<sup>1</sup> From Remanufacturing in the UK: A snapshot of the remanufacturing industry, 2009.

<sup>2</sup> We believe the estimate of the size of the remanufacturing industry in the rail sector was underestimated in the 2009 survey.

<sup>3</sup> Calculated as a percentage of the national expenditure on infrastructure maintenance

NOTE: includes both remanufacturing and refurbishment

NOTE 2: Methodology: A priority list of sectors and products was established. A series of directed conversations were then held to gain comment, opinion and fact on the size of the sectoral remanufacturing industry along with barriers and potential mitigations to encourage remanufacturing. The total value in terms of resource savings, sales (turnover) and employment was determined by scaling the sample to represent the entire market. Growth potential was based on a variety of factors including: additional opportunity for remanufacturing to occur (could more remanufacturing be absorbed in the market), current installed manufacturing or remanufacturing base in Scotland (could additional remanufacturing work be committed in Scotland) and competition with imported remanufactured products (is the Scottish economy competitive).

Analysis of the information collected from interviews and secondary literature sources of these 14 key remanufacturing sectors, shown in Table 2, estimates that remanufacturing contributes £1.1 billion to the Scottish economy. Remanufacturing makes up a larger (and therefore more important) part of the Scottish economy than it does in the whole of the UK.

### 3.3 Key remanufacturing sectors

Remanufacturing in Scotland is dominated by the aerospace maintenance, repair and overhaul (MRO) sector. In addition to this sector, the top four sectors also include energy, rail and automotive.

#### 3.3.1 Aerospace

The word 'remanufacture' is not commonly used in the aerospace industry; the activity is instead referred to as maintenance, repair and overhaul (MRO) activities. MRO activities in Scotland are well-established and are considered to be a significant opportunity for growth within Scotland's aerospace sector.<sup>3</sup> The industry has a centre of excellence developed around Prestwick, and the 'aerospace corridor' between Glasgow and Prestwick includes MRO organisations such as British Airways Maintenance Glasgow, Rolls-Royce in East Kilbride (to be moved to Inchinnan next year) and Spirit AeroSystems in Prestwick.<sup>3</sup> Aerospace is a key sector, not only due to its current dominance of Scottish remanufacturing, but also because of predictions of healthy growth in the MRO sector.

**Spirit AeroSystems (Europe) Limited** is the largest airframe supplier to Airbus and the Prestwick facility is the headquarters of its European maintenance, repair and overhaul operations.

**Rolls-Royce** has a maintenance, repair and overhaul facility currently based in East Kilbride. However, the company is planning to close the plant next year and transfer production to its Inchinnan facility.

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<sup>3</sup> Scottish Development International, Aerospace and defence opportunities in Scotland, 2010 [Link](#) Accessed 25 September, 2014

### 3.3.2 Energy

There is already quite a strong remanufacturing and refurbishment base for the oil and gas and renewable energy sector in Scotland. Organisations active in the sector in Scotland vary from large multi-national corporations to specialist SMEs. The remanufacturing activities also cover a wide range of the sector value chain, ranging from remanufacturing as part of ongoing maintenance and overhaul activities, remanufacturing of leased items and remanufacturing of end-of-life products. The decommissioning of North Sea oil platforms provides a great opportunity to increase the amount of remanufacturing undertaken in this sector. However, the majority of value and volume for remanufacturing will likely arise from remanufacturing lower value steel structures and pipes, rather than the higher value equipment, which will make up much smaller tonnages of available material.

The **Weir Group** remanufactures industrial products, including centrifugal pumps, valves and hydro turbines for use in power plants, refineries and production plants. It has servicing facilities across Scotland.

**Global Energy Group** has facilities in Invergordon, Nigg, Evanton, Dunfermline and Aberdeen. It is involved in rig repairs and upgrades, predominantly of semi-submersible and jack-up rigs.

### 3.3.3 Automotive

Globally, remanufacturing of automotive components is well-established, and this is no different in Scotland. Examples of remanufacturing operations could be found in a range of automotive components, including: engines, transmission and drivetrain components, rotating electrics and ignition parts and air conditioning. There is significant growth potential in the automotive market, particularly with respect to interventions from public procurement.

**Diesel ReCon** remanufactures Cummins diesel engines at its facility in Cumbernauld. The company is currently expanding its product range and looking to expand into component remanufacturing.

**Mackie Automatic & Manual Transmissions** remanufactures transmissions at its facility in Glasgow. The company remanufactures components for OEMs as well as independent clients.

### 3.3.4 Rail

The UK has a stable demand for regular maintenance of its 12,000 strong rail vehicle fleet and related infrastructure. This will include regular vehicle and interior refurbishment and bogie, engine, motor and transformer remanufacturing. There are four major rail refurbishers active in Scotland and at least one company is actively investing in its Scottish facilities due to on-going overhaul contracts. Scotland is well placed to compete with the rest of the UK for work overhauling rolling stock.

**Alstom** has recently been awarded a two year contract to overhaul 40 ScotRail trains. As part of the contract, Alstom are investing in improvements at their Glasgow depot, including a 22m shed extension.

**Brodie Engineering Ltd** offers a range of overhaul and refurbishment services, including heavy maintenance, interior refurbishment and re-paint/re-livery. The company's main facility is based in Kilmarnock.

### 3.4 High-growth remanufacturing sectors

In addition to the four sectors outlined above, the following sectors have been highlighted as high growth in Scotland, albeit from a low base.

#### 3.4.1 ICT and mobile electronics

The ICT and mobile electronics product group includes desktops, laptops, servers, tablets and mobile phones. These products are particularly suitable candidates for refurbishment activities largely due to the high value and complexity of items at the end of their first life. The complexity of the product group means that most of the sector's activities are limited to refurbishment, repair and straight re-use. There is potentially plenty of scope for expansion in the industry: it is claimed that over 80 % of companies dispose of old ICT equipment as waste.

**Sims Recycling Solutions'** facility located near Glasgow primarily recycles end-of-life IT equipment, mobile devices and tablets as well as offering repair and refurbishment of phones and tablets.

**TES-AMM** is a global electronics waste recycler with facilities in Irvine, North Ayrshire. The company offers repair, refurbishment and resale services.

#### 3.4.2 Medical equipment

The medical equipment market is a relatively stable one, largely insulated from the economic cycle. In Scotland, the annual expenditure on medical equipment is £45 million (this does not include capital expenditure)<sup>4</sup> and the replacement value of NHS Scotland medical devices is estimated to be £760 million. Previous research has highlighted that medical imaging is an active area of remanufacturing. The largest Scottish market, NHS Scotland, does not currently buy refurbished (note the industry does not regularly use the term 'remanufactured') medical equipment and this may represent a significant opportunity for the sector.

## 4 Barriers and market failures

The identified barriers and market failures from the sector studies can be broadly categorised into four areas:

- 1 **Supply:** These relate to issues preventing access to the end-of-life product that is the 'core' for remanufacturing.
- 2 **Technical:** These relate to problems faced by remanufacturers that prevent them effectively remanufacturing products.
- 3 **Demand:** These are market barriers preventing increased demand for remanufactured products.
- 4 **Informational:** This is a lack of data and categorisation of remanufacturing that prevents effective government or sector intervention.

### 4.1 Supply

Access to end-of-life product is a major barrier for remanufacturers.

#### Lack of control of collection

There is a need for efficient and cost-effective methods for returning end-of-life products back to remanufacturers. Transport and logistic costs can be a significant barrier to collection. This is a particular problem for Scotland's more sparsely populated regions.

<sup>4</sup> The Scottish Government, Annual state of NHS Scotland assets and facilities report for 2013, 2013 [Link](#) Accessed 2 October, 2014

**Residual liability**

For a wide array of electronic devices, the removal of information and data during the refurbishment process is important. Without reliable and perhaps even certified data wiping processes, consumers may not be willing for their end-of-life products to be used as core for refurbishment and remanufacturing. It can also be an issue for products that can be traced back to the original user such as in the oil and gas industry.

**Availability of spare parts**

Parts are not always readily available or are too expensive for use in remanufacturing and refurbishment activities.

## 4.2 Technical

These barriers are associated with the physical act of remanufacturing by a remanufacturer. They largely revolve around the engineering and logistical challenges associated with remanufacturing.

**Increasing technological complexity**

New remanufacturing techniques and technologies need to be developed to process increasingly complex mechanical, electromechanical and electronic products. With fast moving technologies, there is a danger that older equipment is significantly less efficient and possibly obsolete.

**Intellectual property issues**

Without access to competitively priced spare parts from OEMs, third-party remanufacturers seek the use of compatible components from other outlets. These components may infringe the design rights or intellectual property of the OEM, who may take legal action against remanufacturers.

**Skills/infrastructural**

Remanufacturing requires a technically-minded multi-skilled and flexible workforce to deal with the challenges of remanufacture. These are different from normal manufacturing production processes. A limited skills-base is a drag on how fast a sector can grow. Additionally, initiating new remanufacturing activities in a sector usually requires significantly large capital costs.

**Design for remanufacturing**

Products and components are often difficult to disassemble, particularly where components are glued, riveted, or welded. Where the remanufacturer is not the OEM then lack of availability of technical details about design logic can obstruct efficient disassembly.

## 4.3 Demand

These barriers are associated with the market pull. They are usually associated with customers and their perceptions.

**Consumer/procurer perception**

The level of awareness and reputation of remanufacturing varies between sector and even between procurer group. Overall there is an issue with remanufacturing being poorly understood and purchasers being unwilling to consider remanufactured items even when competitively priced.

**Institutional barriers**

Current public procurement funding patterns do not consider remanufactured products as part of their purchasing criteria. The perceived risks associated with procuring remanufactured products also act as a disincentive for procurers.

**Uncertainty over liability**

For products which have strong health, safety and quality assurance requirements, there may be a natural favour of new items over re-used and remanufactured alternatives.

#### **Low cost competition**

New, low-cost imported products may be perceived to be of higher quality than the remanufactured product even if the tolerances and technical specifications are lower and remanufacturing is limited to high cost products.

## 4.4 Informational

Information barriers are largely associated with the ability of policy makers to effectively target remanufacturers.

#### **Definition**

In certain industries the term 'remanufacturing' is infrequently used or mixed with other phrases that could be classed as remanufacturing.

#### **Data skew**

While there are a large number of SMEs engaged in remanufacturing, data are more readily available from larger remanufacturers and OEMs. A lack of baseline information for SMEs could skew the recognised potential of remanufacturing by under or overestimating the impact of a particular barrier based on large company issues.

## 5 Recommendations

A more comprehensive list of recommendations can be found within the full report.

### 5.1 Supply

**Improve and incentivise core return rates:** Research new collection techniques and technologies. Also, establish a forum for sharing best practice for core collection within Scotland.

**Promote products suitable for remanufacture:** Engage designers and remanufacturers to develop products that are suitable for remanufacturing. Also engage with procurers to ensure that these products are procured.

### 5.2 Technical support

**Share best practice to new market entrants:** Disseminate knowledge and skills from successful remanufacturers using case studies, exchanges/forums and seminars to highlight best practice in a particular industry.

**Identify technical issues through current delivery bodies:** Use current front-line delivery bodies and industry bodies to highlight key issues within the industry.

**Research into advanced remanufacturing technology:** Conduct research into advanced remediation, testing and repair technology possibly through collaborative projects. This could be achieved through vehicles such as Innovate UK, EPSRC and working with the Scottish Institute of Remanufacturing and Scottish Funding Council to engage with the Scottish Innovation Centres.

**Develop cross disciplinary teaching support for remanufacturing:** Develop a unified teaching approach at all levels including undergraduate, post graduate and professional development to train remanufacturing practitioners in business leadership, technical engineering skills and design tools.

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### 5.3 Demand

**Encourage procurement:** Use public procurement to increase demand for remanufactured products in identifiable markets where remanufactured products are present.

**Promote remanufacturing:** Promote remanufacturing to both business leaders and procurers as part of Circular Economy support programmes.

### 5.4 Informational

**Collect data on remanufacturing annually:** Pursue an agreed definition of remanufacturing and engage with the Office of National Statistics to begin collecting annual data on remanufacturing, both from a Scottish perspective and UK-wide.

### 5.5 Overarching recommendations

**Develop links with other nations:** Develop closer ties with other nations to facilitate collaboration and promotion of remanufacturing activity and research. This could include strategic links between universities, or specific industry areas.

**Develop new funding routes:** Investigate alternative funding routes; in particular, the Green Investment Bank, which could provide support for remanufacturing companies.

### 5.6 Benefits of intervention

Using a model developed based on investigation of each of 14 sectors, an estimate on the potential growth of the Scottish remanufacturing industry for turnover is provided in Figure 2 and for employment in Figure 3.

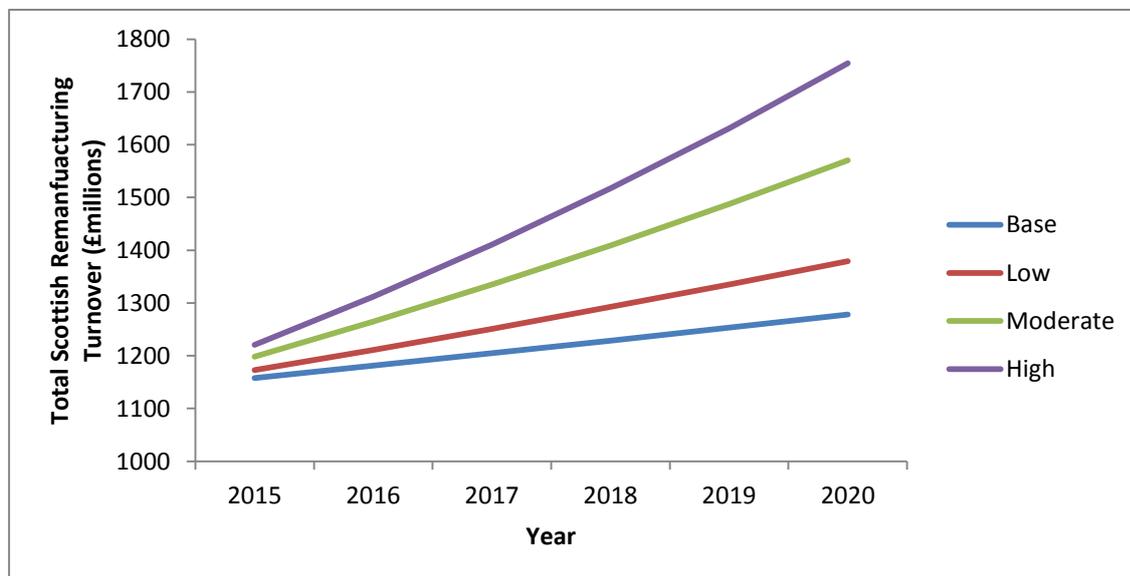
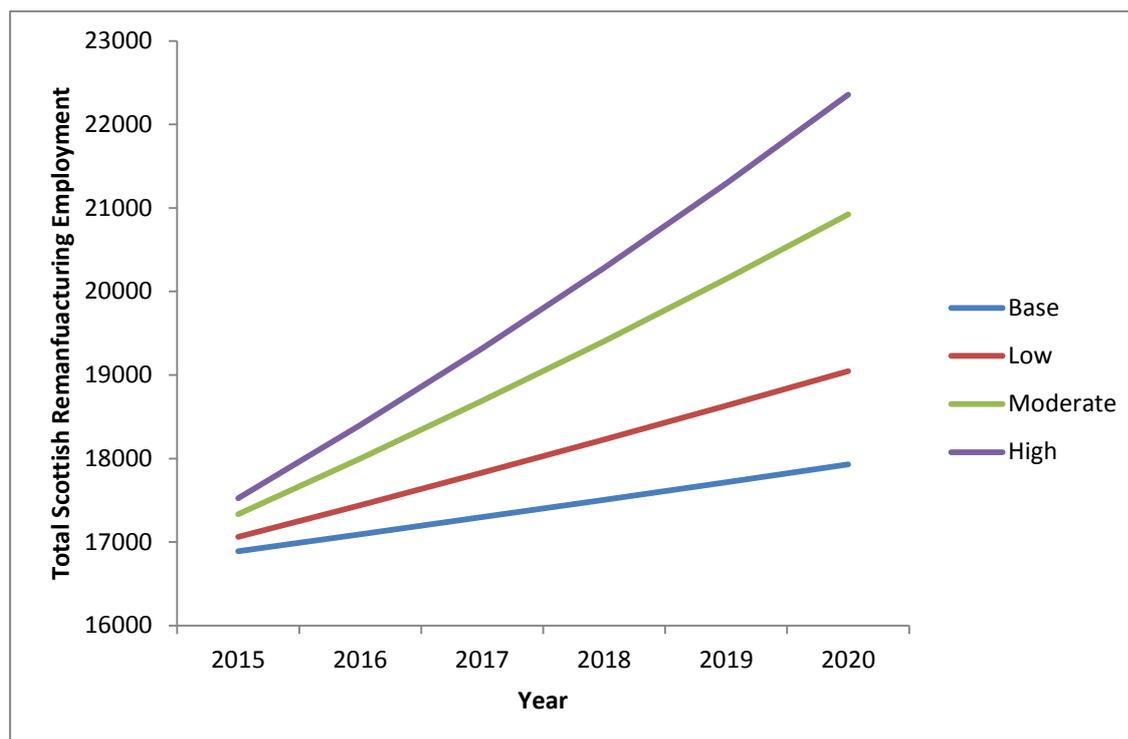


Figure 2 Projected turnover growth in remanufacturing in Scotland based on different levels of policy intervention.



**Figure 3 Projected employment growth in remanufacturing in Scotland based on different levels of policy intervention.**

Based on our illustrative analysis, with significant investment and action by the Scottish government, remanufacturing could add up to £620 million to the Scottish economy; an additional 5,700 jobs could also be created. A full cost benefit analysis would be necessary to fully validate these findings.

## 6 Conclusions

Worldwide, remanufacturing is a significant economic activity. It accounts for about \$110 billion in sales. It is similarly important in Scotland, accounting for £1.1 billion and employing some 17,000 people. Major areas of activity in Scotland are in the aerospace, automotive: parts, energy, and rail. Nascent areas, which with some support could be significant, include ICT and medical equipment.

Identified barriers and recommendations are wide ranging but can be categorised into three key areas of the remanufacturing value chain, namely: supply of core, technical issues preventing remanufacturing and market development issues suppressing demand.

If these challenges can be overcome, remanufacturing activity in Scotland could grow by an additional £620 million by 2020. However, there is no single intervention that will address all the barriers and a mixed approach that will require effort and collaboration by a range of delivery bodies along with Scottish Government and other governments.

If these challenges can be overcome, the goal of developing a more 'Circular' economy will become one step closer. This will benefit both the Scottish economy, in terms of jobs and sales, and the wider environment, through a reduction in resource use and associated carbon impacts.



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