



Scotland and the Circular Economy

A preliminary examination of the opportunities for a circular economy in Scotland

A paper produced by the Ellen MacArthur Foundation in collaboration with Zero Waste Scotland and Scottish Enterprise



About the Ellen MacArthur Foundation

The Ellen MacArthur Foundation was established in 2010 with the aim of inspiring a generation to re-think, re-design and build a positive future through the vision of a circular economy, and focuses on three areas to help accelerate the transition towards it:

Thought leadership—The opportunity for a re-design revolution

The Foundation works to strengthen and communicate the ideas and opportunities around a circular economy, publishing a variety of materials (reports, case studies, educational resources...) as well as using creative and social media. It believes that focusing on designing a restorative model for the future offers a unique opportunity to engage an entire generation when fused with the ability to transfer knowledge, co-create ideas and connect people.

Relying on a network of international experts including key circular economy thinkers and leading academics, the Foundation strives to reinforce the framework's coherence as well as continue to develop it whilst making it available to key target audiences - educational institutions, business, and the public sector.

Business—Catalysing businesses innovation

Since its launch in September 2010 the Foundation has worked together with its Founding Partners (B&Q, BT/Cisco, National Grid and Renault) to embed circular economy thinking within four sectors of the economy.

The Foundation, with the support of the Founding Partners, has gone on to create a programme that focuses on building capacity across the wider business community. The Circular Economy 100 will provide the opportunity for 100 companies to stimulate circular economy innovation, foster collaboration, build capacity and unlock the economic opportunity through accelerator workshops, distance learning modules and an annual summit, hosted by the Foundation and its Founding Partners.

Education—Curriculum development and in-service teacher training

The Foundation works across secondary school and higher education, supporting critical and creative thinking around the circular economy. It relies on a portfolio of over 700 stimulus resources for learners and educators. Equally crucial is the Foundation's approach to learning and 'systems thinking'—the skill of understanding how individual activities interact within a bigger, interconnected world.

Secondary school programmes are lead by Development Field Officers working across the UK, including Scotland. The higher education vision is of a global network of institutions that engage with the key ideas and priorities of the transition to a circular economy. Alongside this is an international masters-level Fellowship Programme featuring an annual summer school that will enable fellowship students to develop circular economy innovation projects within business, engineering and design disciplines. The Foundation has also developed two post-graduate courses including a PGCert in the circular economy and Innovation, Enterprise and Circular Economy MBA, both at Bradford University.

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Summary

A new industrial revolution?

The world is undergoing an unprecedented period of resource stress, driven in part by the scale and speed of demand growth from emerging economies and a decade of increasingly constrained commodity markets^{1,2}.

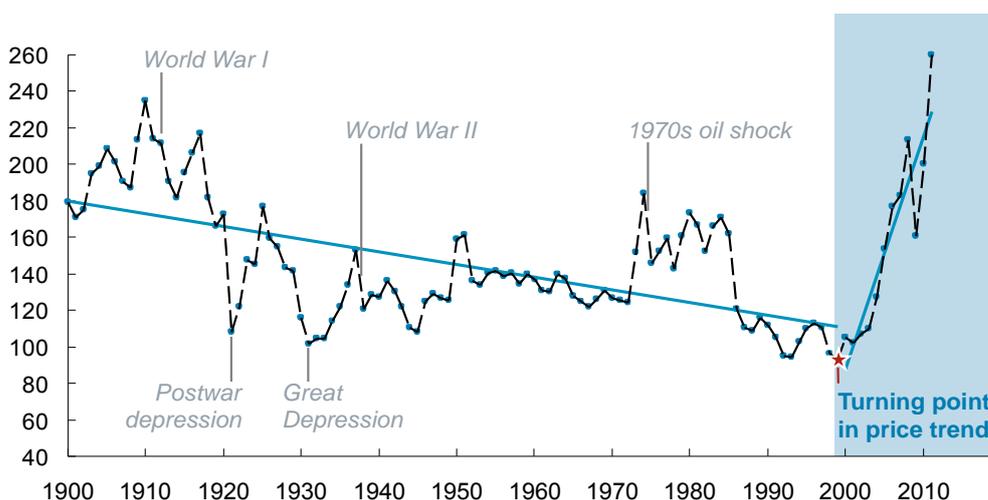
Regardless of whether particular resources are actually running out, the outlook is one of supply disruptions, volatile prices, accelerated environmental degradation, rising political tensions and increased protectionism over resource access.

Coordinated policy action could play a critical role in securing both an economy that is resilient and adaptable to these pressures, and to help drive the deeper levels of innovation in business models, industrial processes, manufacturing and retail that could accelerate the transformation already starting to take place.

In contrast to the previous industrial revolutions, which focused on mass production of goods, current business sector transformations focus on the shift from the sale of goods to the provision of services.

This trend, which could underpin a new global industrial revolution, is being catalysed by the convergence of major technological enablers: innovations in materials science; big data analytics, where large amounts of data are examined to uncover trends and patterns to help customise or adapt services and products; and digital manufacturing techniques such as three-dimensional printing. These enablers, combined with the resource pressures facing global economies, are mobilising a fundamental shift toward a new, and more circular economy.

McKinsey Commodity Price Index (years 1999 - 2001 = 100)¹



¹ Based on arithmetic average of 4 commodity subindices: food, nonfood agricultural items, metals, and energy; 2011 prices based on average of first 8 months of 2011

Sharp price increases in commodities since 2000 have erased all the real price declines of the 20th century

¹ People and the planet. The Royal Society Science Policy Centre report 01/12 Issued: April 2012 DES2470

² Resource Revolution: Meeting the Worlds Energy, Materials Food and Water needs. McKinsey. 2011

The era of the Circular Economy?

In a circular economy, waste material and products become the raw material (food) for industry, commerce and manufacturing. Effectively, waste is designed out of the system, and materials are continuously flowing through the supply chain and are retained by businesses and the economy.

The circular economy is gaining attention as a framework for re-orientating our industrial economy and providing a model for maintaining, and enhancing, economic growth despite the resource constraints we are facing.

The concept is being actively supported by the EU³, the World Economic Forum and early adopter national economies, most notably China and northern European states. The case studies highlighted later in this paper demonstrate that innovative businesses are already seizing the opportunities both in Scotland and globally.

The concept of a circular economy is not new; rather it is the renewal and concerted implementation of a proven concept at a time when technological, economic and policy conditions that make it an increasingly attractive proposition for governments and businesses.

It is an approach that builds on the ground breaking work already under way through Scotland's Zero Waste policy, developing this further through two key related areas of innovation:

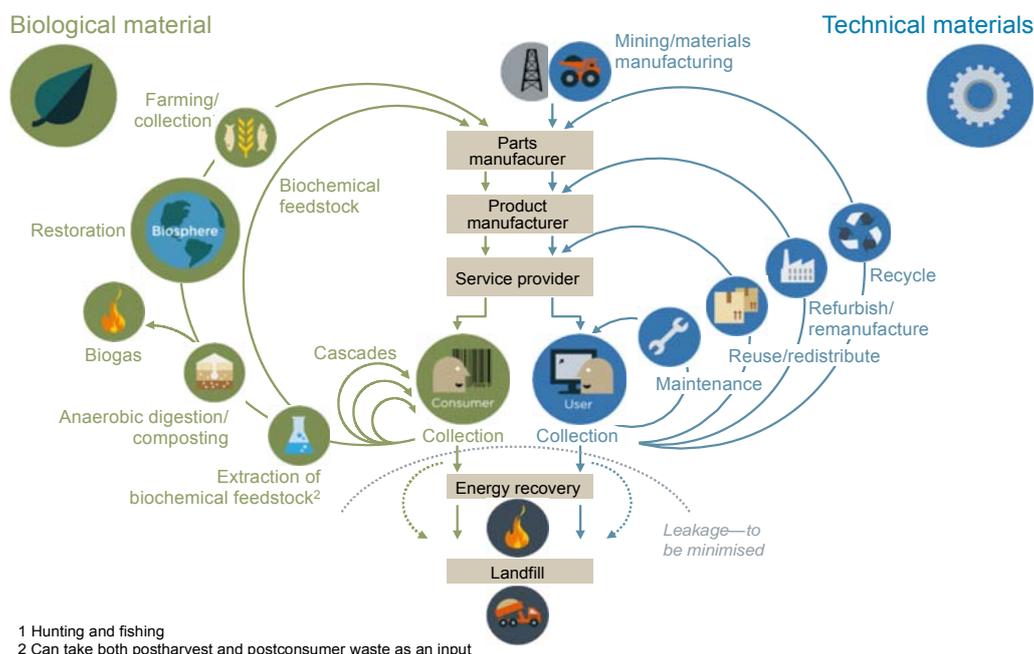
- **“Cradle to cradle” design.** This is based on the conviction that thoughtful design, mirroring the safe, renewing productivity of nature, can create products and economies that are regenerative, not just sustainable. Materials flows in the economy are classified into two types: *biological materials* (e.g. food and wood based products), designed to re-enter the biosphere safely, and *technical materials* (e.g. metals or plastics), which are designed to circulate at high quality without entering the biosphere.
- **Supporting a shift from selling ownership to selling services or performance.** Rethinking and redesigning business models is at the heart of the circular economy concept, and supports the transition to cradle to cradle design. A shift in mind-set from selling products to leasing or selling a service is required to accelerate a change in procurement behaviour that in turn incentivises businesses to retain and recover the product/materials for reuse or remanufacture. This in turn helps stimulate further innovation in design and manufacture.

Together, these concepts not only provide a basis for fundamentally changing the nature of waste in our economy, they simultaneously encourage the adoption of environmentally clean technologies, products and manufacturing.

The change in language and focus that the circular economy approach introduces has also engaged and mobilised boardrooms, the design community and education in a way that traditional waste policy has often failed. In 2012, the Ellen MacArthur Foundation's TearDown labs brought together over 120 teachers, designers, engineers and architects across the UK to explore circular economy thinking and its relationship to product design. In January 2013, the World Economic Forum saw a significant increase in official sessions discussing the opportunities of the circular

³ EU policy statement on making the transition to a Circular Economy (December 2012)

economy, thereby giving further momentum to the launch of the Foundation’s second report on circular economy.



A model of a circular economy where material flows of Biological and Technical materials are shown. The tighter the loops the more beneficial it is to the economy.

Scotland as an early adopter

We are now at a critical juncture as the global economy struggles to make sense of how to generate resilient economic growth, employment and progress. This presents profound challenges not only to our economy but also to our societal behaviours and values.

Early adopters of the circular economy approach could gain a significant advantage in the long-term political, market and business response to resource stresses. Scotland, as a small, adaptable economy, has the opportunity to gain early advantage.

The ambitions outlined in the *Scottish Governments Sustainable Economic Growth Strategy*, its policy connectedness and its industry-led approach to economic development all provide essential ingredients to grasp the opportunities at an early stage. Scotland has also already made good progress on its transition to a circular economy through its ambitious plans to achieve Zero Waste and a 100% renewable energy-powered electricity grid. Zero Waste Scotland and the Resource Efficient Scotland programme are important enablers for this transition, with the enterprise agencies able to help companies grasp the opportunities to stimulate innovation and business growth.

Work has already begun to increase the “circularity” of some of the materials used by some of Scotland’s key industries, such as the Scotch Whisky industry. However the opportunities for other key sectors such as oil and gas, textiles, life sciences and the renewables sector require to be investigated and developed. Major opportunities may arise from increasing the circularity of some of Scotland’s newest industries, such as

the remanufacturing and refurbishment of wind turbines. Across these sectors, a new focus on innovative design, materials and business models has the potential to create early-mover advantages for some firms. The trend toward smaller scale manufacturing, digital services and collaborative industries may also create new opportunities for enhancing Scotland's manufacturing base.

The Ellen MacArthur Foundation has recently formed a global alliance of leading companies (the Circular Economy 100) to develop a programme to advance the circular economy opportunities over a three year period. The Circular Economy 100 (CE100) founder companies, including M&S, Vestas, Ricoh and Morrisons, aim to develop a programme to generate £10bn in economic benefit for participating companies over a three year period. The Foundation is currently looking to establish a similar network for early adopter countries and regions in order to share good practice and act as a knowledge partnerships.

An opportunity worth billions

Last year the Ellen MacArthur Foundation, in collaboration with McKinsey & Company⁴ produced a landmark economic report. It estimated that the adoption of circular economy practices in the manufacture of complex durables with medium lifespans (e.g. motor vehicles, electrical machinery and furniture) could lead to net material cost savings of between USD 340 to 630 billion per year across the EU. This is equivalent to 14 to 23% of the total input costs in EU for the 8 manufacturing sub-sectors studied.

Applying the same methodology to similar manufacturing sub-sectors within Scotland suggests that annual cost savings could amount to between £0.8 to £1.5 billion. This equates to around 5 to 9% of total turnover of these manufacturing sub-sectors in Scotland and compares with the estimated £1.4 billion⁵ annual savings for all businesses in Scotland that could be achieved from implementing simple resource efficiency measures.

A second, more recent report by the Ellen MacArthur Foundation⁶ focuses on the fast-moving consumer goods sector, which accounts for 35% of material inputs to the economy, over 90% of agricultural output, about 60% of total consumer spending and 75% of municipal waste.

The report looked globally at 10 different consumer goods categories, such as apparel, food, beverages or consumer health. It estimated that 20% of material input costs could be saved (up to USD 700 billion) with further benefits including land productivity, soil health and job creation. At a Scottish level, this translates into additional annual cost savings of about £1.5 billion.

Even with the cautious assumptions used in estimating these early-stage economic impacts, it is clear that an early transition to a circular economy offers *significant* benefits to the Scottish economy. Furthermore, in addition to these cost savings attributable to reduced material inputs, the circular economy also offers a range of wider economic benefits to Scotland, such as increased economic resilience, new business opportunities and job creation.

⁴ [Towards the circular economy – economic and business rationale for an accelerated transition](#), Ellen MacArthur Foundation, January 2012

⁵ Scottish Government Saving Scotland's Resources Consultation 2012

⁶ [Towards the circular economy – opportunities for the consumer goods sector](#), Ellen MacArthur Foundation, January 2013

"The circular economy represents a clear and proven opportunity for businesses around the world. Our new initiative brings cohesion and focus to this opportunity and allows businesses to share experiences, learn from best practice and to work together to achieve real business benefits. Each of the members of the CE100 has made a commitment to a circular economy initiative. In total we anticipate that this have a value of more than \$10 billion, encouraging innovation, investment and job creation."

Extract from EMF CE100 objectives

Enablers and barriers

A number of barriers exist that could, if not tackled, prevent or slow down the transition to a circular economy:

- Industry barriers: product design promoting obsolescence, preventing easy disassembly or chemical decontamination; lack of business awareness of commercial opportunities; reluctance to innovate owing to perceived risks;
- Consumer barriers: weak incentives for product repair or upgrade; low level of trust concerning remanufactured goods;
- Business environment: absence of fiscal incentives; poor access to capital to invest in new infrastructure and innovation; weaknesses in financial and legal frameworks.

In addressing these barriers, emphasis should be placed on creating the market conditions needed to support early adopter companies, while establishing a longer-term framework for mainstreaming these innovations across key sectors.

The following areas provide good starting points for seizing these opportunities:

- **Leadership:** political and industry-led leadership is essential to help understand the opportunities and inspire others to grasp them.
- **Public procurement:** currently a fragmented process, public procurement offers a huge opportunity to incentivise firms to offer new types of products and services by driving innovation and collaboration.
- **Market incentives and signals:** re-balancing market support mechanisms and regulations to encourage re-use, remanufacture and effective recycling.
- **Education:** in addition to knowledge transfer and building business capability, the shift to a circular economy needs to take place in tandem with a transformation of the education system.
- **Innovation and research:** creating a circular economy hub for innovation in manufacturing and product design, that bridges traditionally sector-focused work, could help give Scottish companies an early advantage in the global market.
- **Finance sector:** a shift from selling ownership to selling services will require more innovative financing models. The Scottish finance sector could be well placed to develop the new financial tools and services needed to support this transition.

Scotland and the Circular Economy- Full Report

A collective enlightenment?

“In the early eighteenth century in Scotland there emerged a cluster of philosophers, social scientists, moralists and others who together helped to shape what came to be known as the Enlightenment. They explored the assumptions, values and principles of the move from a pre-industrial to an industrial age, the rise of secularism and reason”⁷

Today we live in a rapidly evolving, networked world in which the accepted principles of how our economy and society operate are again being challenged. Science has moved on so that the worldview we increasingly recognise is of a dynamic world, full of networks and flows, more complex, more interdependent, more dynamic than we used to imagine.

In this world, resource depletion, increasing commodity price volatility, climate change and biodiversity loss are all fast becoming mainstream business issues. The overriding problem is the “linear” nature of our economy, where our “take – make-dispose” approach is leading to scarcity, volatility, and pricing levels that are becoming unaffordable for our manufacturing base.

The Circular Economy approach potentially provides a solution to some of these crises. A way to re-think the future. This system-wide change is what characterised the enthusiasm of the likes of Adam Smith, David Hume or James Watt. Remember too that what they said was often controversial. Making the world anew is challenging.

So it seems appropriate then that a second cluster of individuals and organisations should emerge in Scotland seeking to reinvent our economy as a circular one.

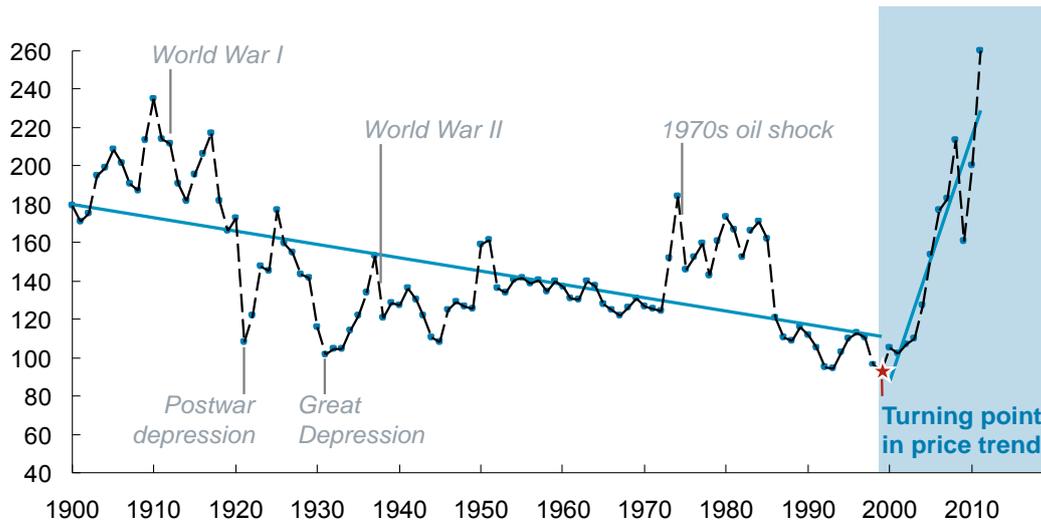
What is the circular economy?

Over the past decade, the global economy has had to cope with unprecedented increases in commodity prices together with their increasing volatility (see Figure 1).

In a circular economy waste is designed out of the system, replaced by the notion of by-product – a material no longer useful to its last user but potentially highly valuable to other applications. In this framework, both technical and biological materials are continuously flowing through the supply chain, as illustrated in the diagram on Figure 2.

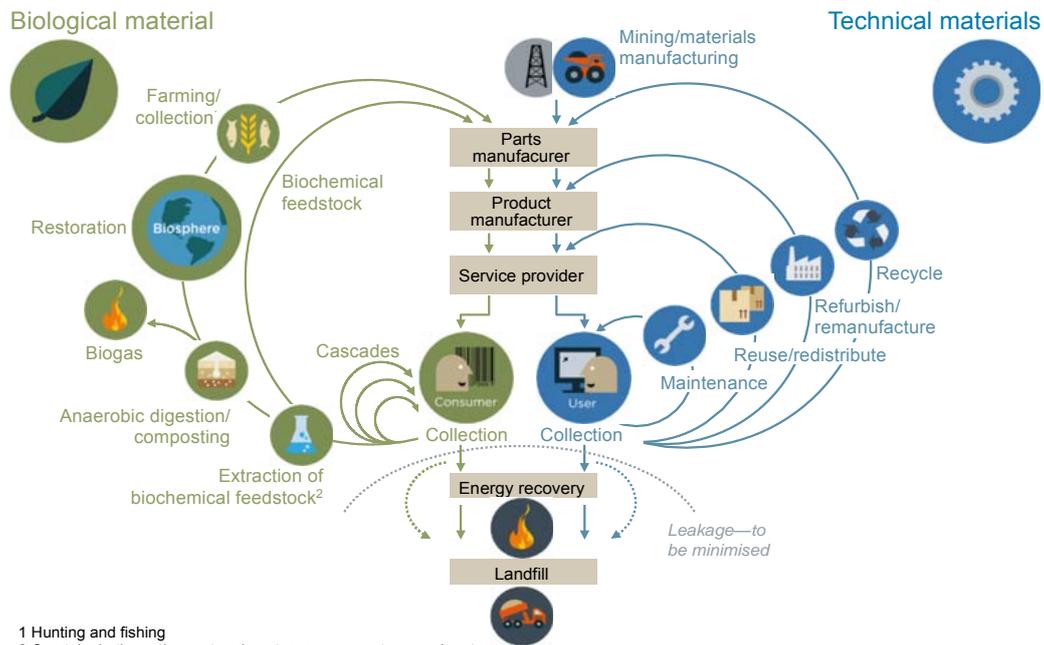
⁷ Invitation to the first International Future Forum meeting (2000)

McKinsey Commodity Price Index (years 1999 - 2001 = 100)¹



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Figure 1: Sharp price increases in commodities since 2000 have erased all the real price declines of the 20th century



¹ Hunting and fishing
² Can take both postharvest and postconsumer waste as an input

Figure 2: The circular economy - an industrial system that is restorative by design

The circular economy implies significant changes to product design to promote longevity and the reuse of goods. Waste is eliminated by designing products for a cycle of disassembly and reuse:

- Economic value is created by minimising loss of material, labour, energy and capital embedded in products, and maintaining products in 'tight' re-use, remanufacturing or recycling circles for as long as possible;

- The number of cycles is optimised for cascaded use across the value chain. For example, cotton clothing is reused first as second-hand clothing, then crosses to the furniture industry as fibre-fill in upholstery, and the fibre-fill is later reused in insulation for construction – in each case substituting for virgin materials into the economy – before the cotton fibres are safely returned to the biosphere; and
- Uncontaminated material streams help maximising the effectiveness of collection and redistribution while maintaining quality. Material productivity gains thereby accumulate over time, compared to a conventional linear system.

Adopting a ‘closed system’ approach to optimising the value of resources helps to increase economic resilience. Supply chains with many connections and scales are able to better withstand external shocks than systems built simply for efficiency. Thinking in circular rather than linear systems also helps to enable innovation.

It is helpful to consider five component elements of the circular economy. These are not mutually exclusive and often occur in combination:

- A. Circular product design and innovation** – product re-design promotes standardisation and modularisation so that they can be easily disassembled and the value of resources is retained within ‘tight’ reverse circles
- B. Product re-use, repair and remanufacturing** – ensuring longevity of use requires manufacturers to re-use and remanufacture products in the system for as long as possible. This tips the balance away from ‘production’ to ‘maintenance’. It also demands new competences to ensure the effective collection and sorting of products along reverse cycles.
- C. Innovative business models** – creating value-adding business propositions around better-designed, long-lasting products. Disruptive business opportunities based on performance (e.g. shared ownership, hire and leasing and pay-for-use models) can compete successfully against low cost, ownership-based linear models. They also enable much closer interaction with customers (‘users’) and increased personalisation and customisation.
- D. Renewable energy and materials substitution** – while circular systems help optimise efficient resource use, they also avoid unnecessary exploitation of resources in the first place. Switching from fossil-fuels to renewable energy, and substituting non-renewable and scarce resources for renewable alternatives are important aspects.
- E. Effective supply chain and cross-sectoral collaboration** – a circular economy demands changes at all levels of the economy to drive collaborative solutions. Policy alignment, incentives, industry standards, access to finance, infrastructure and education are all vital elements.
- F. Re-use of waste, heat and energy** – treating otherwise wasted outputs of business processes as the inputs for new processes reduces costs, boosts productivity and opens up new commercial opportunities.

Underpinning all of these five elements are collaborative solutions across supply chains and sectors, together with aspects of a supportive business environment – policy alignment, incentives, industry standards, access to finance, infrastructure and

education – which are all essential ingredients for success.

The convergence of four market trends make the transition possible: consumer behaviour beginning to favour access over ownership; information technologies enabling complex reverse logistics and materials tracking; the demand for stable and resilient products growing on the part of investors and financial institutions; and finally, expectations of tighter environmental regulations to safeguard our natural resources.

Already, we can see companies in Scotland adopting different aspects of circular economy principles to drive innovation, reduce costs, increase economic resilience and deepen relationships with customers.

Company Case Study - Mainetti

Mainetti is the leading manufacturer of garment hangers, providing around 300 million pieces to retailers and producers and meeting almost half of the annual UK demand. Having established a reputation as a leading manufacturer Mainetti has now diversified and become an industry-leading recycler, with over two-thirds of the firm's output produced from recycled processes. This shift in focus has allowed Mainetti to reduce its carbon overheads and its productivity costs. Graham Wilson, production and engineering manager at Mainetti, says:

"Although we've been recycling since the late 1980s, we've changed greatly over the last seven years, to answer retail sector demand for 'closed loop' supply. Those boxes under the counter in the clothes stores, that fill up with hangers from purchases, find their way back to us, where we sort, recycle, and remanufacture into new products, sending them right back out to our customers."

Scotland is well-placed to benefit

The strong policy fit between the circular economy and the objectives of the Scottish Government means that Scotland is well positioned to be able to capture the benefits of this emerging opportunity. Essentially, the circular economy is a *growth*-oriented agenda, maximising the value of resources already within the economy and global supply chains. This aligns well with the Scottish Government's overall purpose of stimulating *sustainable economic growth* and the essential focus in the Government Economic Strategy on using innovation to drive new economic value. In addition, at a time of rising and increasingly volatile commodity prices, the promise of greater economic resilience and competitiveness is an attractive means of supporting economic recovery.

More broadly, the circular economy aligns well with Scotland's ambitious climate change agenda. It supports the shift towards a less energy- and resource-intensive society, bringing environmental as well as economic benefits. Furthermore, Scotland's Zero Waste Plan already has circularity at the heart of its vision; embracing the opportunities set out in this paper will help accelerate the progress already being made.

Some examples of the changes and innovations already in progress include:

1. **Biological Materials:** The treatment of organic waste from householders and businesses is an area where joined up policy-making and innovation by companies has supported a rapid change and increase in circularity. Through Zero Waste Scotland, capital grant funding was provided for investment in

new Anaerobic Digestion and In-vessel Composting facilities to enable organic waste to be processed into a fertilizer and soil improver; replacing increasingly expensive fossil fuel based products. At the same time grant support was also provided to companies and local authorities to introduce collections for food waste to provide the supply for these facilities. This change was then backed up by Waste (Scotland) Regulations 2012 banning organic waste to landfill and requiring separate collections for the material. Further work has been undertaken to ensure the new fertilizer products created meet product standards to provide confidence for users to make the switch from non-renewable fertilizers. (See also the Keenan's case study below).

Company case study - Keenan Recycling Limited

Keenan recycle around 40,000 tonnes of organic waste per year. Their high quality grade compost is highly effective and replaces chemical fertiliser. It is so popular with farmers that demand is outstripping supply. Their food waste collection service has enabled customers to increase their recycling rates by up to 30%, saving an estimated £168,000 per year. With over £2 million of the £5 million invested in the business spent within a two-mile radius of the site, it is a key contributor to the local economy. Keenan collect food waste free-of-charge from six schools and give them free compost back. In 2009 and 2010 they won the Scottish Waste and Resources Award for demonstrating Best Practice and Innovation.

- 2. Innovation in Construction:** During 2012 Zero Waste Scotland launched a Resource Efficient House competition to help the building sector develop a house design that minimises waste and is designed not only for construction but also deconstruction. The house will be built on a demonstration site owned by the Building Research Establishment in Central Scotland. The design competition held has been won by a consortium led by Tigh Grian Ltd and work will commence in early 2013. The project includes the fitting out of the house with appliances and fixtures providing another opportunity to demonstrate products designed with circular economy thinking. In line with the wider themes of the Innovation Park, the home must also be affordable and suitably repeatable for mass house building.
- 3. Enabling Support:** Resource Efficient Scotland is a new business support programme being launched in April by the Scottish Government. This brings together three previous programmes which covered resource use, waste, water use and energy. This new joined up approach will enable support to businesses to be provided in a more holistic fashion. The new programme also includes targeted sector initiatives, offering the opportunity for key business sectors to be supported towards achieving greater circularity.
- 4. Funding Support for Innovation:** Closed loop reprocessing for key materials, such as plastics, is being supported through a loan fund operated by Scottish Enterprise. A general aim of this fund is to assist company innovation and establish new closed loop reprocessing industries in Scotland (see also the case study below where innovation funding was provided to prove the production line).

Company case study - Panel 2 Panel

A new manufacturing process has been developed and the first product to be launched is a washroom panel. The panels will be manufactured at facilities in Dalbeattie, Kirkcudbrightshire and formed completely from plastic waste

products. It is envisaged that for every 1000 panels produced, 56 tonnes of mixed plastic waste, primarily High Impact Polystyrene (HIPS) will be diverted from landfill. Within two years of operation, more than 1,100 tonnes of Scottish waste will be diverted from landfill.

The panels have the strength and stiffness to carry sanitary-ware and other fixtures on the front surface and hidden plumbing components on the rear surface. The panels are an integral part of a new product range “System 21” being launched by Ideal Standard. To deliver on the Ideal Standard contract a bespoke, semi-automated full production system is being installed and will be commissioned in Dalbeattie by April 2013.

Further Scottish case studies are provided in Appendix 1 alongside three examples of international companies moving to business models with greater circularity.

The size of the prize

High-level analysis suggests that the circular economy offers significant economic benefits to individual firms and to the Scottish economy as a whole. To date, this analysis has focused on certain manufacturing sub-sectors together with the fast moving consumer goods sector.

In a report by the Ellen MacArthur Foundation, analysis at an EU level by McKinsey & Company⁴ in 2011 estimated that the adoption of circular economy practices in the **manufacture of medium-lived complex goods** (e.g. motor vehicles, electrical machinery and furniture) could lead to net material cost savings of between USD 340 to 630 billion per year. This is equivalent to 14 to 23% of the total input costs in EU for the 8 manufacturing sub-sectors studied. It is important to note that this estimate was based on the following assumptions (further detail is provided in the Annex):

- This is a conservative estimate. The 8 sub-sectors represent a little under half of the contribution the EU manufacturing sector makes to overall EU GDP.
- The estimation is based on commodity prices in 2011.

Applying this analysis to similar manufacturing sub-sectors within Scotland (by apportioning the material cost savings according to Scotland’s share of total EU turnover) suggests that annual cost savings could amount to between £0.8 and £1.5 billion. This equates to around 5 to 9% of total turnover of these manufacturing sub-sectors in Scotland.

For Scotland, given the available data, the sub-sectors included were: computer, electronic and optical products; electrical equipment; machinery and equipment not elsewhere classified; motor vehicles, trailers and semi-trailers; other transport equipment; furniture; and other manufacturing. Owing to the method of apportioning cost savings, it is assumed that the cost structure of these sub-sectors in Scotland is similar to that at an EU level, and that the adoption of circular economy principles is of a similar level.

A second, more recent report by the Ellen MacArthur Foundation⁶ focused on the **fast-moving consumer goods sector**, which accounts for 35% of material inputs to the economy, over 90% of agricultural output, about 60% of total consumer spending and 75% of municipal waste. The report studied, on a global scale, 10 different consumer goods categories: Apparel, Beauty and Personal Care, Beverages, Consumer Health, Fresh Food, Home Care, Packaged Food, Pet Care, Tissues and Hygiene, and Tobacco. Materials savings were scaled up using the cost of materials

inputs for each of the ten fast-moving consumer goods categories. It was estimated that 20% of material input costs could be saved (up to USD 700 billion) with further benefits including land productivity, soil health and job creation.

Using a range of consumable product categories as a proxy, this suggests additional annual cost savings of USD 2.4 billion (about £1.5 billion) for Scotland.

In addition to the cost savings attributable to reduced material inputs, the circular economy also offers a range of wider economic benefits to Scotland:

- Emerging business opportunities in logistics, repair, remanufacture, design and innovation would be expected to generate new employment. A proportion would be genuinely additional while others are likely to be displaced from other activities and locations. For instance, roughly one-third of the labour inputs to global manufacturing supply chains are related to resource extraction and two-thirds directly associated with manufacturing. In a circular economy, the balance of labour inputs would shift to produce re-use, repair and remanufacturing with a greater share of this likely to be located locally close to end-users.
- Increased economic resilience and reduced exposure to higher costs and increased volatility of global commodities such as copper and other critical materials.

In terms of wider social benefits, Walter Stahel (author of “The Performance Economy”) writes that “*One of the biggest mistakes in our current system is to look at the workforce as a fixed ‘stock’ of people fitting certain precise criteria, and not to look at the multiple benefits that could bring a more organic view*”. For instance, this could translate into bringing qualified pensioners into schools to act as teaching assistants or finding ways to keep retired nurses and doctors who are willing to remain active in the system. “*Where there is a strong health and care sector there are skills that can be harnessed for the benefit of society as a whole*”, says Stahel. This view puts the emphasis on the social capital building element of the performance economy, one of the building blocks of a systemic circular model. This element goes beyond strict economic gains, but can be construed as equally important as it enhances social cohesion and potentially dramatically reduces costs associated to the degradation of well-being.

It should be emphasised that this early analysis of potential economic benefits needs to be developed much further, informed by real-time evidence of circular economy practices and with reference to the nature and structure of Scotland’s business base. It is intended that this will be addressed in the next phase of research.

Sectoral benefits to the Scottish economy

The Government Economic Strategy (GES) provides a strong focus on the growth of industry ‘clusters’ in which Scotland has competitive strengths in a global context. Scotland’s industry-led approach offers a sound platform for providing a test-bed for circular economy developments and realising new growth opportunities. Already, there is close alignment between many industry strategies, overseen by the Industry Leadership Groups, and the principles embedded within circular economy thinking.

The scale of the opportunity would appear to be most significant in relation to particular sectoral supply chains, for example:

Food and Drink

- Food and beverage manufacture generates significant volumes of organic by-products. These are currently mostly used as animal feed but also offer alternative uses such as energy production through anaerobic digestion, and the production of biofuels⁸.
- Around 1.59 million tonnes p.a. of food waste and industrial effluents are generated (excluding the whisky sector). Around two-thirds of these already go to effluent treatment in the dairy and drinks sector, however with a different approach they could support an additional 10-20 anaerobic digestion plants across Scotland.

Energy

- The shift to a circular economy promises a significant reduction in overall energy consumption. Renault's remanufactured engines, for example, require 25% of the energy needed to produce a new engine in a linear model.
- Energy consumption reduction would in turn enable to reach a threshold at which renewable energies can completely take over. Scotland's aggressive approach to exploiting its renewable energy resources – with 35% of Scottish electricity coming from renewables in 2011⁹ – puts it in a strong position to capitalise on the circular economy transition. Future developments in wave and tidal technologies will further increase its self-sufficiency in renewable energy.
- The end-of-life use of oil & gas and renewable energy infrastructure should now be considered. Large wind turbines, for example, use permanent magnets containing rare earth metals, which constitute one of the 14 critical raw materials defined by the European Commission¹⁰.

Construction

- On average, 70 to 80% of construction and demolition waste is being discarded in developed countries^{Error! Bookmark not defined.}, which represents a sizeable untapped opportunity. The sector is currently struggling in a challenging economic climate; adopting circular economy thinking can open up new opportunities and offer new revenue streams.
- Designing buildings for easy disassembly using modular designs, sparks innovation, diverts materials from demolition waste and reduces the cost of waste disposal. The Building Research Establishment's facility at Ravenscraig, focused on innovation in materials and building techniques, has the potential to create early-mover advantage for some construction firms.

Chemical and Life Sciences

- Research is already underway to investigate how bio-feedstocks can replace fossil fuels for a range of chemical and industrial processes, as well as provide enzymes (catalysts) for industrial processes and transport needs. Given Scotland's strong expertise in these highly productive, research-intensive sectors, the country is well placed to support innovation in industrial biotechnology.
- Chemical Sciences Scotland has identified the need to re-engineer 'fully sustainable manufacturing processes' within its recently refreshed industry strategy.

⁸ Organic arisings in the UK Drink sector, WRAP, June 2012

⁹ [Scotland beats 2011 green energy target](#), Scottish Government, March 2012

¹⁰ [Raw materials: Defining 'critical' raw materials](#), European Commission, 2010

- A specific opportunity may be the medical devices sub-sector. With the Scottish NHS as a major customer it offers a potential test-bed for circular economy applications.

Winners and losers

While we are convinced that the transition towards a circular economy would bring net positive benefits for the Scottish economy – and would also be profitable at the company level – a few areas of economic activity may, in the long term, experience change and negative impacts, particularly where sectors or companies are slow to adapt to the changing business environment. Changes in economic activity and employment though are of course an inevitable consequence of waves of innovation.

We anticipate, for example, that:

- The mining industry might contract owing to a reduced demand for raw materials. It is, however, important to stress that this industry only amounts to ~1% of all jobs in Scotland¹¹.
- In terms of adaptation, industries with materials handling / transformation expertise can find a very good outlet for their skills and infrastructure in “materials handling” (re-processing, recycling...) or by becoming materials pools management units, which lie at the heart of a circular economy.
- Somewhat counter-intuitively, companies currently active in waste treatment could be negatively impacted since a reduction in mixed waste materials would likely translate into narrower profit margins and stronger competition for them. This should however be regarded as a natural evolution of the sector and those concerned companies would still certainly benefit from early adoption, especially if they move into more circular treatments for separated waste products and materials.

Enablers and barriers

In its transition to circular economy, Scotland is not starting from scratch. Indeed, several initiatives and case studies already exist, as highlighted by the *Scotland is well placed to benefit* section above and the case studies in Appendix 1.

In all economies, a number of barriers however currently exist that could, if not tackled, prevent or slow down the transition to a circular economy. These relate to the industry, consumers and the wider business environment:

- Industry barriers: e.g. product design promoting obsolescence, preventing easy disassembly or allowing chemical decontamination; lack of business awareness of commercial opportunities; reluctance to innovate owing to perceived risks;
- Consumer barriers: e.g. weak incentives for product repair or upgrade; low level of trust concerning remanufactured goods;
- Business environment: e.g. absence of fiscal incentives; poor access to capital to invest in new infrastructure and innovation; Directives promoting recycling over re-use; weaknesses in financial and legal frameworks.

There are some additional barriers that we believe are particular to the Scottish context:

¹¹ [ONS](#), Workforce jobs by region and industry, 2011 – includes central and local government employment.

- The structure of Scotland's business base, dominated by smaller enterprises, might indicate that companies are more risk averse than those elsewhere. Furthermore, a recent report suggests that Scottish business leaders tend to demonstrate marginally less ambition to grow and innovate than other countries of UK¹². This tendency is likely to be amplified by the current economic climate; and
- Data limitations may hinder the accurate assessment of the potential impact of the circular economy. Scottish-level data sets do not always align well with those at EU and UK levels and smaller sample sizes may introduce uncertainties.

The following areas provide good starting points for seizing these opportunities:

- **Leadership:** political and industry-led leadership is essential to help understand the opportunities and inspire others to grasp them.
- **Public procurement:** currently a fragmented process, public procurement offers a huge opportunity to incentivise firms to offer new types of products and services by driving innovation and collaboration.
- **Market incentives and signals:** re-balancing market support mechanisms and regulations to encourage re-use or remanufacture and closed loop recycling.
- **Education:** in addition to knowledge transfer and building business capability, the shift to a circular economy needs to take place in tandem with a transformation of the education system.
- **Innovation and research:** creating a circular economy hub for innovation in manufacturing and product design, that bridges traditional sector focused work, could help give Scottish companies an early advantage in the global market.
- **Finance sector:** a shift from selling ownership to selling services will require more innovative financing models. The Scottish finance sector could be well placed to develop the new financial tools and services needed to support this transition.

Potential next steps

In this document, we aimed to provide an initial assessment of the potential benefits of the circular economy in Scotland and of the actions that can be taken to accelerate the transition. Having 'made the case' for the circular economy we believe that three key actions are now needed over the next six months, providing the impetus necessary to translate the concept into action.

- **Undertake detailed analysis:** Further, more detailed analysis is needed to assess the anticipated economic (and social/environmental) impacts of the circular economy in Scotland. It is proposed that this research should analyse material flows across the Scottish economy, identifying the scope for introducing new technology solutions and business practices to optimise the value of closed-loop supply chains. It should also clearly highlight the sectors / supply chains offering greatest economic potential within Scotland. A

¹² [Business Growth ambitions amongst SMEs](#) (2011), commissioned by Scottish Enterprise, the Department for Business, Innovation and Skills, the Welsh Government and InvestNI.

particular output could include the identification of demonstrator projects that could be supported by Industry Leadership Groups or industry bodies and subsequently scaled-up.

- **Develop a strong industry-led approach:** Industry leadership is crucial to help overcome barriers to action and identify deliverable solutions that fit the Scottish context. Early adopter companies are best placed to identify the right approaches and inspire others to take action. A short-life leadership group could be appointed to help champion the changes that are needed for effective delivery.
- **Create a supportive business environment:** In addition to a strong policy approach, a wide range of other support is necessary to enable change to take place and overcome potential barriers. These include raising business awareness; supporting collaboration between firms; using public procurement to incentivise change; ensuring alignment of regulatory and legislative mechanisms; promoting innovation and investment; and stimulating consumer demand. The transition to a circular economy will gradually take shape over time; policy consistency and alignment of other support mechanisms is essential.

Appendix 1 – Case Studies

Scottish case studies

These case studies demonstrate that there are already many companies commencing the transition to a circular economy approach through their own products and services. We have categorised them according to building blocks of a circular economy¹³:

- Product re-design and innovation (e.g. material choice, design for disassembly, design to last)
- New business models (e.g. collaborative consumption, leasing models, pay-per-use models)
- Cascades and reverse logistics (which enable in turn the repair, reuse, remanufacture or effective recycling of products or by-products)
- Cross-sector and cross-value chain collaboration (e.g. information sharing, networks)

Diageo – Cascades and reverse logistics

Diageo is currently installing a Clearfleau anaerobic digestion system (a high rate liquid process) on its site at the Dailuaine Distillery on Speyside. This will be operational shortly and will treat the effluents produced by the process, converting them into biogas, and hence providing power and heat for the distillery operation, whilst also reducing effluent discharge.

HP – Reverse logistics (repair, reuse and remanufacturing), new business models

HP recently opened a Technology Renewal Centre in Erskine, Scotland. This is owned and operated by HP Financial Services, the company's leasing and asset management subsidiary. The centre offers a range of IT legacy asset management and recovery services to HP's customers in Europe, including the remarketing and recycling of IT equipment. The Centre refurbishes a range of products, both HP and non-HP, including PCs, servers, network products, storage, etc. from the 8,400-square-foot facility, which was previously an HP/Compaq manufacturing site.

A primary purpose of the facility is to realise the value of products the company takes back at the end of leasing agreements. The residual value of devices is an important part of the business, helping the company keep costs down and stay competitive with its leasing contracts. The most effective way to maximise value is to see products re-sold in the marketplace, so it's in the company's interest to refurbish as much as possible.

OI – Reverse logistics (effective recycling)

Owens Illinois (OI) has three glass furnaces producing flint (clear glass) bottles, green bottles and amber bottles in Alloa. OI currently produce around 2 million bottles per day and up to 800 million per annum. They do this using up to 20% recycled flint, 70% recycled green and 25% recycled amber glass. However they have the capacity to accept more recycled material; up to 30% flint, 85% green and

¹³ More details on these building blocks can be found in the reports "Towards the Circular Economy"

50% amber. Currently they are using around 60,000 tonnes of cullet (waste glass) in a closed loop recycling process but have the capacity to use over 100,000 tonnes.

Celtic Renewables – Product re-design and innovation, cascades

Celtic Renewables Ltd is an innovative start-up company formed to commercialise a process for producing a superior next generation biofuel (and other high value sustainable products) from the by-products of biological industries. The company is initially focused on the £4 billion Scottish Malt Whisky industry as a ripe resource for developing bio-butanol – a next generation biofuel. Biobutanol has 25% more energy per unit volume than bioethanol; in sharp contrast to ethanol, it can run in unmodified engines at any blend with petrol and may also be blended with diesel and biodiesel; it is less corrosive than bioethanol and can be transported using existing infrastructures.

The whisky industry annually produces 1,600 million litres of pot ale and 500,000 tonnes of draff which could be converted into biofuel as a direct substitute for fossil-derived fuel, thereby reducing oil consumption and CO₂ emissions, while also providing energy security – particularly in remote/rural areas where the whisky industry is prevalent. The Celtic Renewables Ltd production process also produces other sustainable chemicals, acetone and ethanol, as well as high grade sustainable animal feed.

CCL North – Reverse logistics (repair, reuse, and remanufacturing)

Based in Irvine CCL are involved with secure IT recycling and refurbishment as well as WEEE recycling. They are currently looking at setting up a Re-use facility for general WEEE. Their partner companies Restructa and Restructa LCD (also both based in Irvine) handle the recycling of CRT televisions/monitors and LCD televisions/monitors respectively.

Vegware – Product re-design and innovation (material substitution)

Vegware are the only company in the UK to develop, manufacture and distribute a full range of completely compostable food packaging and catering disposables. Per kilo of resin, the carbon footprint of conventional plastic (PET) is 3.4kg, whereas for Vegware corn starch bioplastic (PLA) it's 0.75kg. Swapping a PET product for an equivalent PLA product made in the same place and transported in the same way, gives a carbon saving of 2.65kg per kilo of finished product. All Vegware products are plastic-free and have certification to prove they can compost in under 12 weeks. All products are designed to break down together with food waste, and in the UK they help customers set up food waste recycling through the Food Waste Network. Vegware are based in Edinburgh and currently has operational bases in the UK and USA with distribution throughout Europe and North America.

Dryden Aqua Technologies – Product re-design and innovation, Reverse logistics (effective recycling)

Dryden Aqua Technologies have developed Activated Filter Media (AFM) – a chemically reconstituted glass medium which filters water. AFM was developed to replace filter grade sand in all mechanical water treatment applications. Research has demonstrated that savings of 30% could be made on operating and energy costs. AFM, manufactured from recycled green glass, is used in over 40,000 installations worldwide and is the only activated glass filtration media approved by the Scottish Drinking Water Regulator. AFM can give up to a 50% better performance than sand, and uses less chemicals and produces less than 10% of the disinfection by-products associated with standard filter systems. It also adsorbs dissolved organics and can control levels of arsenic, iron and manganese. The business is currently investing in the World's first reconstituted glass factory facility

outside Edinburgh. It will process an initial 30,000 tonnes per year of waste container glass - turn a proportion into a high performance water filtration media, which once used, can be recycled for reuse.

Argent Energy – Reverse logistics and cascades

Argent Energy is the UK's leading waste-to-energy biodiesel producer and has pioneered the large scale commercial production of biodiesel in the UK. Their plant, near Motherwell in Scotland, has the capacity to produce approximately 50 million litres a year of high quality biodiesel. Argent Energy use locally collected used cooking oil and unprocessed tallow. This not only helps to add value to the Scottish red meat sector, but also further improves Argent's carbon footprint; where last year the production of 45,000 tonnes of biodiesel successfully displaced 282,000 tonnes of CO₂, when compared with mineral diesel. In 2011, they finished installing new equipment which has the capacity to accept approximately 5,000 tonnes per annum; turning materials such as fats, oils and greases (FOGs) that have been recovered from sewers, grease traps and effluent plants into high quality biodiesel. This state of the art technology is a world first. With Water companies in the UK currently spending £15m per annum clearing used cooking oil from their sewers and 75% of the 200,000 drain clearance call-outs every year involving used cooking oil. This new technology will allow Argent Energy to access a wider variety of feedstock material; whilst helping other sectors to reduce their carbon footprint.

BPI Recycled Products - Reverse logistics (effective recycling)

BPI Recycled Products is a division of British Polythene Industries PLC, and they are Europe's largest recycler of polythene waste recycling over 70,000 tonnes of material each year. The Dumfries site, established in the 1990s, recycles waste farm plastics, keeping reusable polythene in circulation and out of landfill. The recycled materials are then used to create refuse sacks, and Plaswood - an industrial strength plastic wood alternative.

Spruce Carpets - Reverse logistics (repair, reuse, and remanufacturing)

Spruce Carpets, a community enterprise, uplift, refurbish, supply, deliver and fit used carpets and carpet tiles for residential, domestic and commercial customers. Working with flooring contractors and property managers, their reclaimed stock is acquired via their uplift and reuse service. The carpets/tiles are then inspected, cleaned, refurbished and sold on.

AG Barr – Reverse logistics (reuse)

AG Barr produces soft drinks for the UK market and internationally. With some Iconic Scottish Brands such as "Irn Bru" they are one of the biggest companies in the sector. Barr's continue to provide reusable glass bottles for a range of their soft drinks including Irn Bru, lemonade, and cola. The bottles have a 30 pence deposit which is refunded on return and the bottles are collected on behalf of Barrs by many local retailers.

International case studies¹⁴

Ricoh – Japan – Reverse logistics (re-use, repair and remanufacturing), new business models (leasing model)

Copiers and printers returning from Ricoh's leasing programme are inspected, dismantled, and go through an extensive renewal process — including key components replacement and software update — before re-entering the market

¹⁴ The international case studies are selected from the website of the Ellen MacArthur Foundation, http://www.ellenmacarthurfoundation.org/case_studies

under the GreenLine label with the same warranty scheme that is applied to new devices. Ricoh's objectives are to reduce the input of new resources by 25% by 2020 and by 87.5% by 2050 from the level of 2007.

Desso – Netherlands – Product re-design, reverse logistics (re-use, repair and remanufacturing), new business models (leasing model)

Flooring company Desso have been one of the pioneers of the “Cradle to Cradle” approach, and were the first carpet manufacturer in EMEA to gain C2C certification. The company continues to innovate around the principles of a circular economy, extending these products to a large portfolio of clients in both carpet and artificial grass divisions.

Stef Kranendijk was CEO of Desso between April 2007 – October 2012, and a key driving force in re-thinking the business model of the company. He explains that “the idea is to become a service industry, relying on a leasing system: then you don't buy the product, you only pay for its use, which means materials remain our responsibility and of course it's not our interest to see them wasted, at the end everybody wins. The business model works and makes sense, we've gained a competitive edge whilst making better products, when in 2009 eight out of the ten biggest carpet manufacturers recorded considerable losses.

Digital Lumens – USA – Product redesign, new business model (leasing model)

Digital Lumens offers integrated Intelligent Lighting Systems, combining LEDs, networking and software to reduce customers' lighting-related energy use by up to 90 percent. As of 2013, the company is planning to start offering these solutions as a service rather than an equipment sale, which is attractive to companies that don't have to pay a large up front capital cost.

“Industrial lighting is dominated by antique and criminally inefficient lighting based on the original Edison light bulb”, says Tom Pincince, CEO of Digital Lumens. This enormous potential for improvement has led the start-up to develop the first Intelligent LED Lighting System for industrial facilities – such as warehouses, manufacturing, cold storage, and maintenance depots – where lighting is one of the largest energy expenses because of 24/7 occupancy and typically high ceilings. They enabled Ardo UK, a leading supplier of frozen fruit, vegetables and carbohydrates, to reduce their annual lighting-related energy costs by 97% by upgrading an 80,000-cubic-meter mobile racking cold storage facility in Kent, England to the Digital Lumens Intelligent Lighting System. “The savings from one Digital Lumens project were equivalent to performing complete energy efficiency projects in 2,400 homes,” says Tom.

Ecovative – USA – Product re-design and innovation (material substitution)

Ecovative's products are fully compostable alternatives to synthetic materials such as petroleum-based expanded plastics. They are made of mycelium grown in and around agriculture byproducts, acting thereby as a glue, and can take any shape needed. At the end of its use, the material can be simply composted at home without needing any special equipment.

In 2010, Ecovative commercially launched a portfolio of protective packaging products, originally called EcoCradle®. Ecovative has supplied their protective packaging to a growing number of Fortune 500 companies including Dell.

Appendix 2 – Methodology Notes

Methodology and limits of the opportunity analyses

Cost savings in the manufacturing of medium-lived complex products: The analysis consisted of first calculating which fraction of the total EU turnover for the concerned sectors was from Scottish businesses. We then applied this ratio to the cost savings calculated in the Ellen MacArthur Foundation / McKinsey & Company report. Although effective at providing a first idea of the potential, this approach implies a few underlying assumptions that limit its precision:

- It is assumed that the cost structure of the Scottish companies is on average the same as in the rest of EU. A more detailed analysis should compare the total material and energy costs of these industries to the ones in EU.
- The approach also assumes that Scotland is on average as advanced as EU overall in implementation of circular setups.
- The turnover figures for Scotland are the ones declared in March 2012¹⁵. The EU comparison consists mostly of 2008 figures¹⁶ (and 2009 figures where 2008 were missing) while the report was based on 2007 cost figures in EU.
- Due to the nature of data available, the industry sectors considered for the analysis are a proxy of the ones used in the report. These are motor vehicles; machinery and equipment; electrical machinery & apparatus; other transport; furniture; radio, TV and communication; medical precision and optical equipment; office machinery and computers. Based on available data, the proxy used for the analysis was the following categories: computer, electronic and optical products; electrical equipment; machinery and equipment n.e.c.; motor vehicles, trailers and semi-trailers; other transport equipment; furniture; other manufacturing.

Cost savings in the manufacturing of consumables: The report studied 10 different consumer goods categories: Apparel, Beauty and Personal Care, Beverages, Consumer Health, Fresh Food, Home Care, Packaged Food, Pet Care, Tissues and Hygiene, and Tobacco. Materials savings have been scaled up using the cost of materials inputs for each of the ten fast-moving consumer goods categories. The costs of materials inputs were derived using end consumption data from Euromonitor for 2011 and the share of materials inputs (in terms of retail price of the products) for each category. These percentages of material input were obtained through interviews with experts for each of the ten consumer goods categories.

Materials savings have been defined as savings from the application of profitable circular practices. The analysis has shown that this ratio would be affected by local factors such as labour costs, organisation / business structures and processes, and infrastructure already in place. To adjust for this, we have varied the savings ratio across three geographic regions: Canada and the U.S., Europe, and the other large economic regions (Asia, Africa, and South America).

¹⁵ [Businesses in Scotland 2012](#), Scottish Government, November 2012 – excludes central and local government employment

¹⁶ Annual detailed enterprise statistics for industry (NACE Rev.2 B-E) [sbs_na_ind_r2], Eurostat, 2012

The research for the second report determined cost savings that can be realised with circular setups as percentage of the total consumption in the categories considered. The analysis on consumables for Scotland follows this approach.

Consumption data in the United Kingdom was given as market value in Datamonitor reports. The categories chosen to describe the different product types covered in the report are described in Table 1. The consumption in Scotland was then estimated to be in the same proportion to the overall consumption in UK as their populations. This leads to a potential imprecision, since it assumes consumption behaviour to be similar in Scotland as it is in the UK overall. The caveats concerning cost structure and the stage reached in the implementation of circular setups, described for the analysis in durables, also applies to this analysis as well.

Categories in report	Categories from Datamonitor
Apparel	Apparel Retail
Beauty and personal care	Personal Hygiene + Personal Products
Beverages	Soft drinks + Alcoholic drinks
Consumer Health	OTC Pharmaceuticals
Home care	Household products
Fresh food	Organic food + Meat, fish & poultry + Fruit & Vegetables + Meat
Packaged food	Biscuits + Confectionary + Breakfast cereals + Canned food + Chilled & Deli food + Bread & rolls + Dairy
Pet care	Pet care
Tissue and hygiene	Not included
Tobacco	Tobacco

Table 1: Product categories from Datamonitor selected to represent the product categories in the report.