Re-designing a more circular Scottish economy

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Abstract

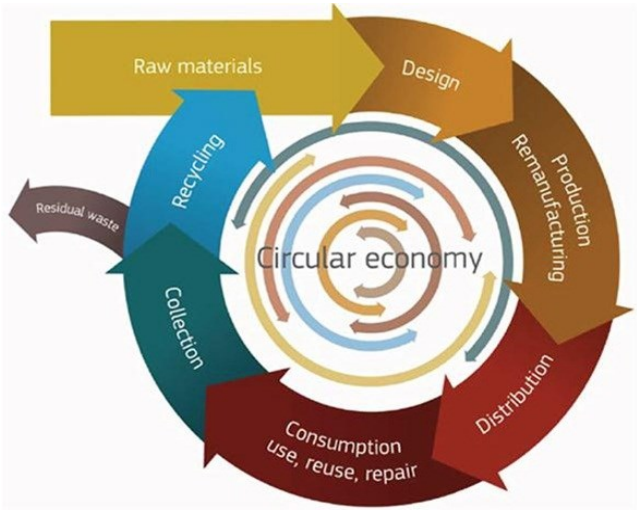
Policies to develop a more circular economy can unlock opportunities that change how businesses, supply chains and economies could operate in the 21st Century. Such approaches build on the application of earlier concepts of industrial ecology (Frosch and Gallopoulos, 1989), cradle-to-cradle (Braungart and MacDonough, 2002) and the performance economy (Stahel, 2010). This article explores the nature, benefits, barriers and enablers of the shift towards a more circular Scottish economy, drawing on the global evidence and the programme of research undertaken by the Scottish Government and its public sector partners. In particular, it assesses the nature and scale of the opportunities in two of Scotland's growth sectors – oil & gas and the bioeconomy – and highlights the policy and evidence issues that will be important to support the transition to a more circular – and sustainable – Scottish economy.

Key words: circular economy, Scottish economy, oil and gas, bioeconomy, Scottish Government, evidence base, methodologies

I What is the 'circular economy'?

In a world of finite resources and rapid population growth the circular economy offers a new and exciting perspective. It is an approach that shifts the focus from the ever more efficient use of resources to *re-using* those resources across the economy (Figure 1). Such an approach not only boosts productivity, by reducing demand for and the cost of raw materials, but also stimulates innovation in terms of product re-design, re-use and re-manufacture.

Figure 1: The circular economy[1]



[1] *European Commission (2014) Towards a circular economy: A zero waste programme for Europe*

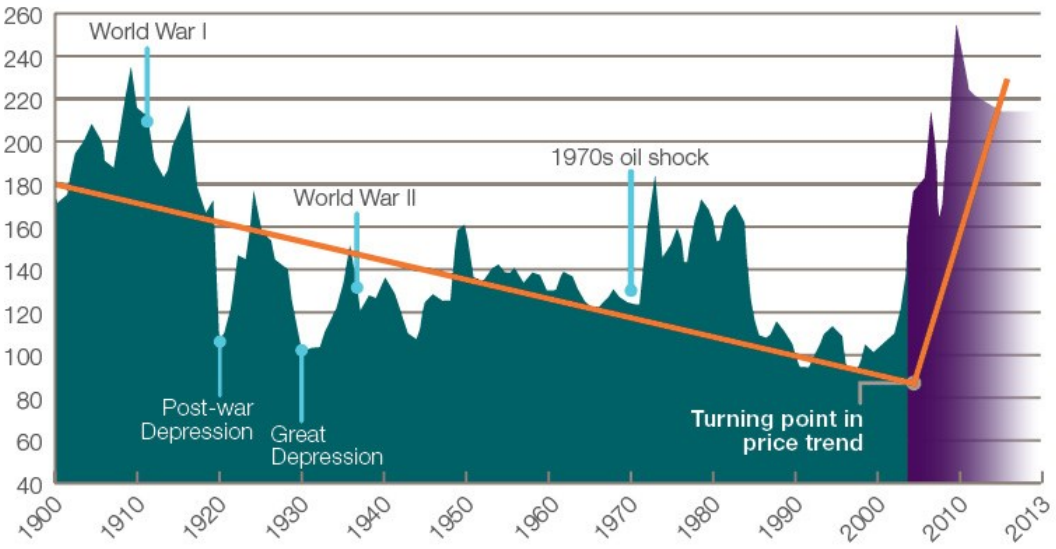
Circular thinking presents a vision for how businesses and nations could operate in the 21st century, a vision increasingly supported by leading economies, global businesses and institutions such as the EU and World Economic Forum. For companies, circular models help reduce business risk from volatile and costly global commodities such as copper, lithium and phosphorous. Re-using materials also helps to create new value by, for example, substituting finite with renewable materials, re-using resources through remanufacturing and adopting new business models that optimise the performance of products through their shared use.

For governments and businesses, the circular economy offers ways to drive sustainable growth and innovation, decoupled from the consumption of virgin natural resources, whilst creating jobs and reducing environmental impacts. Together with many leading economies such as the Netherlands, Belgium and Finland, Scotland is actively investigating the scale and nature of circular economy opportunities and re-aligning its policy frameworks to enable businesses and individuals to grasp the opportunities[2].

II Shifting from linear to circular systems

The circular economy is an alternative to a more traditional linear economy in which products (and energy) tend to be used over a short period then discarded as waste. This is an economic system focused on producing and consuming as cheaply as possible, and one that is not sustainable given surging demand from emerging economies and pressures on the cost and supply of global commodities.

Figure 2: McKinsey commodity price index[3]



Between 2000 and 2010, resource limits and rapid growth in global demand erased the decline in commodity prices achieved over the previous century (see Figure 2). Commodity price volatility is now a

[2] *Scottish Government (2015) Making things last: Consultation on creating a more circular economy in Scotland*
[3] ***IPPR (2014) The wasteline: Redefining 'waste' and improving resource management policy. IPPR***

key economic concern. However, this does not imply that future commodity price increases are inevitable. Following the rapid rises of 2000-10, prices have fallen significantly (notably for oil), driven by weakening global economic growth and (in the case of oil), oversupply. Substitution of expensive commodities by new materials and new processes can also help alleviate resource price pressures. Indeed, adopting circular economy approaches in themselves will help reduce demand for virgin resources.

The benefit of the circular economy to the macro economy is fourfold, it:

- reduces commodity price pressures;
- limits exposure to resource price volatility;
- reduces country/supply risks; and
- develops domestic, circular industries which partially substitute for imports.

The origins of the circular economy concept date from the 1970s when the idea of a regenerative society was born, in which processes renew the sources of energy and materials they consume. Walter Stahel developed a model of 'loops' in which resources and energy are maintained and regenerated via product life extension, long-life goods, reconditioning activities and waste prevention. The substitution of products by services (or labour) is also an important aspect of circular economy thinking with its emphasis on helping to create jobs and boost economic competitiveness and was later referred to by Stahel as the 'performance economy'[4].

Borrowing from natural biological concepts (focusing on the circulation of organic and inorganic nutrients circulating in healthy, safe metabolisms), Braungart and McDonough's cradle-to-cradle[5] concept focuses on the critical importance of design for effective resource use. They identified two main categories of materials, technical (e.g. plastics and metals) and biological, each underpinned by different design principles for their recovery and reuse. To them, products containing technical materials, for example, should ideally be designed to promote ease of disassembly so that their constituent parts can be upgraded or reused.

The third key theoretical foundation to circular economy thinking is industrial ecology[6]. This adopts a systems-level approach to eliminate waste by designing processes in which outputs from one process serve as an input to another. Variously referred to as industrial symbiosis or closed-loop systems, industrial ecology aims to mimic living systems as far as possible, optimising material, water and energy use.

All three conceptual approaches focus on the re-design of production systems to promote product longevity, re-use and modular upgrading, using either renewable resources or optimising the use of non-renewable materials.

[4] *Stahel, W. (2010) The performance economy. MacMillan*
[5] *Braungart M. & McDonough W. (2002) Cradle to cradle: Remaking the way we make things. North Point Press*
[6] *Frosch, R.A. & Gallopoulos, N.E. (1989). Strategies for Manufacturing. Scientific American 261 (3): 144–152.*

More recently, the circular economy concept has been cited as a means of decoupling global resource use from economic growth[7]. While resource efficiency measures simply slow the use of virgin materials, circularity could lead to a step-change. The UN Environment Programme estimates that global annual consumption of minerals, ores, fossil fuels and biomass could triple between today and 2050, while it is also estimated that global energy and water use could increase by 50% by 2030[8]. The collaborative economy is a term used to describe a range of more radical business models that represent a shift from product ownership towards rental, leasing or shared access to goods or services. Online marketplaces (such as eBay), car sharing (eg ZipCar) and access to under-used capacity (eg Airbnb) all illustrate ways in which new economic value can be created through the optimal use of existing resources flowing through the economy.

III Why is the circular economy a timely policy issue for Scotland?

At a global level the concept of the circular economy is gaining traction and has been discussed at the World Economic Forum[9] in Davos each year since 2012. Much of the recent drive for the circular economy has been led by the Ellen MacArthur Foundation (EMF) which has focused on, in particular, championing business opportunities. Global companies such as Renault, Michelin and Philips are all members of the EMF's Circular Economy 100 Network, which aims to build scale and business capabilities in re-designing how supply chains and economies could operate in future. Indeed, in a recent UN study conducted by Accenture, 36% of 1,000 CEOs across 25 industries planned to use circular economy practices such as shifting from product-ownership to service-based models, engaging in the sharing economy or recapturing and re-using valuable materials[10].

Governments have also responded to this agenda, recognising the strategic importance of circular solutions to the twin challenges of productivity growth and environmental degradation[11]. Following initial political wrangling the European Commission is now about to launch a more ambitious circular economy 'package'. The Scottish Government became the first regional member of the Circular Economy 100 Network and has now been joined by other leading countries and regions including Denmark, Taiwan, Catalonia and Wallonia.

The Scottish Government's overarching strategy, *Scotland's Economic Strategy*[12], highlights the role of circular economy opportunities in addressing both inclusive growth and competitiveness, helping to create a more resilient and rebalanced economy:

"[W]e are creating conditions for a more circular economy that helps companies embrace new business models and manufacturing processes, and which transforms used products into assets that support industries like remanufacturing, reuse, product disassembly and reprocessing. Remanufacturing is transforming how parts and products are produced. In doing so, it helps industries minimise their use of

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[7] *World Economic Forum (2014) Towards the Circular Economy: Accelerating the scale-up across global supply chains.*
Prepared in collaboration with Ellen MacArthur Foundation and McKinsey & Company
[8] *See Chatham House (2012) A Global Redesign? Shaping the Circular Economy*
[9] *https://agenda.weforum.org/2015/01/collaboration-drives-circular-economy/*
[10] *UN Global Compact (2013) Accenture CEO Survey*
[11] *Ellen MacArthur Foundation (2015) Delivering the circular economy: A toolkit for policymakers*
[12] *Scottish Government (2015) Scotland's Economic Strategy*

raw materials, while reducing energy and water use. Sectors as diverse as aerospace, energy, automotive, IT and medical equipment industries are already benefiting from this transformation". (p46)

This policy stance represents a significant development on Scotland's Zero Waste policies and re-positions the circular economy as a means to stimulate sustainable economic growth as much as to manage environmental resources. Following its *Making Things Last*[13] consultation, the Scottish Government intends to publish its circular economy programme by late 2015 to provide strategic direction and policy certainty to help unlock economic and business opportunities for Scotland.

IV What are the benefits of a shift to a more circular Scottish economy?

In broad terms, the circular economy offers a wide range of benefits to the economy and to individual businesses and their supply chains. These include:

- Increased productivity and competitiveness: eliminating wasted materials and maximising the value of products and materials;
- Stimulating product and supply chain innovation: working across supply chains to re-design products for a lifetime of disassembly and re-use;
- Stronger customer relationships: developing processes to enable product maintenance and refurbishment rather than disposal, and collaborative use rather than product ownership;
- Greater resilience: to supply constraints and price spikes in relation to finite raw materials such as copper and indium; and
- Job creation: moving value-creation from product manufacture 'downstream' to servicing, customer co-creation and material re-use and recovery.

As governments focus on promoting the circular economy the evidence base is strengthening. Influential research by McKinsey[14] for the Ellen MacArthur Foundation suggests transformative economic impacts for the EU economy. Its analysis of selected manufacturing and fast-moving consumer goods (FMCG) sub-sectors indicates significant cost savings and productivity gains as well as increased land productivity and job creation:

- material cost savings of £220bn - £410bn per annum in relation to the manufacture of complex durables with medium lifespans (e.g. motor vehicles, electrical machinery and furniture). This is equivalent to 14% to 23% of total input costs in the EU for the eight manufacturing sub-sectors studied;
- savings of up to 20% on material inputs (up to £450bn) for the fast-moving consumer goods (FMCG)[15] sector. This relates to ten consumer goods categories including clothing, food, beverages and consumer health, which account for 35% of material inputs to the economy,

[13] *Scottish Government (2015) Making things last – Consultation on creating a more circular economy in Scotland*
[14] *Ellen MacArthur Foundation (2012) Towards the circular economy – economic and business rationale for an accelerated transition*
[15] *Ellen MacArthur Foundation (2013) Towards the circular economy – opportunities for the consumer goods sector*

over 90% of agricultural output, 60% of total consumer spending and 75% of municipal waste; and

- increased biological resilience in terms of higher land productivity, less waste in the food value chain and the return of nutrients to the soil.

Further research by the Ellen MacArthur Foundation, in conjunction with Scottish Enterprise and Zero Waste Scotland[16], applied this same methodology to similar manufacturing and consumer goods sub-sectors in Scotland and it identified proportionally similar cost savings:

- annual cost savings of £0.8bn -1.5bn (5-9% of turnover) for the manufacture of medium-life durables, resulting from the reduction of material inputs such as metals and plastics; and
- annual cost savings of £1.5bn from a reduction in materials used in the ten consumer goods categories.

The scale of anticipated impacts in Scotland compares favourably with similar studies in the Netherlands and Sweden:

- Over the next decade circular practices could grow the Netherlands' economy by an additional £5.35bn annually, creating 54,000 new jobs[17]. The current value of the circular economy in the Netherlands for 17 product categories from the metal and electrical sectors is estimated to be £2.43bn, growing by an additional £420mn each year.
- A Swedish case study by the Club of Rome[18] modelled the impacts of a combination of increased resource efficiency, the use of renewable energy and a shift to a materially-efficient circular and performance-based economy. It found that together, these measures could lead to an increase in employment of 100,000 (2-3% of the labour force), an improved trade balance of >3% of GDP and a 70% reduction in CO_2 emissions.

As well as the economic drivers for a more circular approach, there are also significant environmental benefits, ranging from lower greenhouse gas (GHG) emissions, less pressure on water resources, virgin materials and habitats, and reduced pollution.

These various studies all demonstrate that the circular economy could deliver significant employment, economic growth and environmental benefits at regional, national and supranational levels. However, the evidence base needs to develop further. In particular, the use of different methodologies and assumptions means that comparative analysis between study findings is currently difficult.

[16] *Ellen MacArthur Foundation, Scottish Enterprise and Zero Waste Scotland (2013) Scotland and the circular economy: A preliminary examination of the opportunities for a circular economy in Scotland*
[17] *TNO (2013) Opportunities for a circular economy in the Netherlands*
[18] *Club of Rome (2015) The circular economy and benefits for society: Swedish case study shows jobs and climate as clear winners*

V Where are circular economy opportunities likely to be greatest?

Clearly the economic impacts of the circular economy will not be equal across all market sectors. In particular, the 2012[19] and 2013[20] McKinsey studies adopted a sectoral focus, assuming that impacts could be greatest for the manufacture of certain durables (i.e. technical materials) and selected fast-moving consumer goods (i.e. bio-materials).

Figure 3: The RESOLVE framework[21]

REGENERATE	• Shift to renewable energy and materials • Reclaim, retain and restore health of ecosystems • Return recovered biological resources to the biosphere
SHARE	• Share assets (eg cars, rooms, appliances) • Reuse/second hand • Prolong life through maintenance, design for durability, upgradability etc.
OPTIMISE	• Increase the performance / efficiency of products • Remove waste in production and supply chains • Leverage big data, automation and remote sensing
LOOP	• Remanufacture products or components • Recycle materials • Digest anaerobically • Extract biochemicals from organic waste
VIRTUALISE	• Dematerialise directly (eg books, music, films, travel) • Dematerialise indirectly (eg online shopping)
EXCHANGE	• Replace old with advanced, renewable materials • Apply new technologies (eg 3D printing) • Choose new products/services (eg multimodal transport)

[19] *Ellen MacArthur Foundation (2012) Towards the circular economy – economic and business rationale for an accelerated transition*
[20] *Ellen MacArthur Foundation (2013) Towards the circular economy – opportunities for the consumer goods sector*
[21] *McKinsey Center for Business and Environment and Ellen MacArthur Foundation (2015) Growth within: A circular economy vision for a competitive Europe*

The most recent 2015 McKinsey study[22] takes this a stage further and provides a helpful framework to analyse the kinds of business model and technological innovations that comprise the circular economy. The researchers used assumptions about technological and behavioural changes in the period to 2050 to understand where we might expect impacts to be greatest. The 'RESOLVE' framework in Figure 3 describes six broad areas of business opportunity, enabled by new technologies, behaviours and business models. All of them represent different ways in which the use of physical assets is increased, prolonging their life, and shifting resource use from finite to renewable sources.

McKinsey applied this framework to three areas of household expenditure, mobility, food and housing, which together account for 60% of average EU household spend and 80% of resource consumption. Informed by expert views on technologies to be available by 2020, they identified significant savings over the period to 2050: 60-80% for mobility, 25-40% for food and 25-35% for housing. They anticipate some of the greatest savings in the following areas:

- *Mobility*: the widespread adoption of car-sharing schemes and other business models that change demand patterns, the electrification of inter-modal transport systems and light-weighting of vehicles using materials such as aluminium and carbon fibre;
- *Food:* the application of ICT, automation and satellite systems to radically increase food productivity, reduce waste, increase yields and better match supply and demand; and
- *Built environment*: widespread adoption of new technologies including modular construction, 3D printing and smart energy management systems, and better space utilisation and space-sharing. Together, these innovations are expected to reduce building use costs and thereby increase demand.

VI Scottish case studies: the oil and gas and bio-economy sectors

A closer look at the oil & gas and bio-economy sectors provides an insight into the specific opportunities and challenges for Scotland in shifting towards a more circular economy. These case studies are drawn from a joint evidence-gathering programme carried out in 2014-15 by The Scottish Government, the Enterprise Agencies, Zero Waste Scotland and SEPA. The research programme set out to identify the nature and scale of circular economy opportunities for Scotland. It focused on several industry sectors together with economy-wide opportunities such as design, regulatory change and public procurement.

(i) Oil and gas decommissioning

Two key issues affecting Scotland's oil and gas industry include the sharp fall in the oil price since late 2014 and North Sea decommissioning, where between 2014 and 2023 around 400,000 tonnes of infrastructure will be removed for dismantling, recovery, recycling or disposal. Together, these two issues mean there is a strong focus on cost reduction and asset life extension, with total decommissioning spend alone forecast to reach £46bn in real terms by 2040 and average £1.8bn per annum until 2020.

[22] *McKinsey Center for Business and Environment and Ellen MacArthur Foundation (2015) Growth within: A circular economy vision for a competitive Europe*

Circular economy business and supply chain practices have the potential to add significantly to the end-of-life value of oil and gas assets deployed in Scottish waters. It is estimated that the recycling (scrap) value for the 'average' North Sea installation is around £173,000 but this could be increased by up to an additional £900,000 if all of the assets were reused. The returns are likely to be greatest where high-value equipment such as pumps, valves and cranes can be re-used and remanufactured. However, the majority of value and volume for remanufacturing will come from lower value steel structures and pipes.

As yet, re-use and remanufacturing are not mainstream practices in the context of decommissioning. Only a handful of small companies have spotted a market niche in buying higher-value assets able to be re-used, such as oil rig accommodation blocks for example. It is often more convenient for the large infrastructure owners to sell assets to specialist recyclers rather than seek buyers on the re-use market. Unfortunately, the vast majority of steel so far decommissioned has been lost to the Scottish economy, particularly given that there is no large-scale steel reprocessing plant north of the border and only small markets currently exist for reused and remanufactured products.

However, the focus on decommissioning by industry bodies such as Decom North Sea and Oil and Gas UK, supported by the Oil and Gas Innovation Centre, Energy Skills Taskforce and public sector partners, means that capturing the value of circular practices is now a growing priority. There is also stronger public support for remanufacturing more generally from the Scottish Manufacturing Advisory Service and the recently-established Scottish Institute for Remanufacture based at the University of Strathclyde, which offer company development and technical expertise respectively. Together these should help grow remanufacturing in the oil and gas industry as well as in the aerospace, rail and automotive sectors, where remanufacturing has been firmly established for many years[23].

(ii) Bioeconomy

In circular economy terms the bioeconomy refers to waste streams that have chemical or biological properties that can be reprocessed to produce base materials for new products or to substitute for conventional sources. Bio-based waste can often be converted ("upcycled") into higher-value materials to provide additional income streams for companies. Such higher-value materials include chemicals and biofuels; food ingredients such as protein, oils, carbohydrates and fibre; fibres for use in textiles, paper or similar uses; substrate or nutrient feed for new biological production (e.g. mushroom cultivation, algae/insect production for animal feed); construction materials; and sources of renewable heat and/or power.

Research focusing on the beer, whisky and fish sectors[24] suggests that an additional £0.5–£0.8bn annual turnover could be added by diverting waste streams to higher-value markets. Examples include processing whisky and brewing by-products into biofuels, chemicals and animal/fish feeds, and extracting proteins from fish wastes for use in human food supplements.

[23] *Scottish Government and partners (2015) Remanufacturing Study*
[24] *Scottish Government and partners (2015) Sector Study – Beer, Whisky and Fish*

Figure 4: Bio-based circular economy opportunities for Scotland[25]

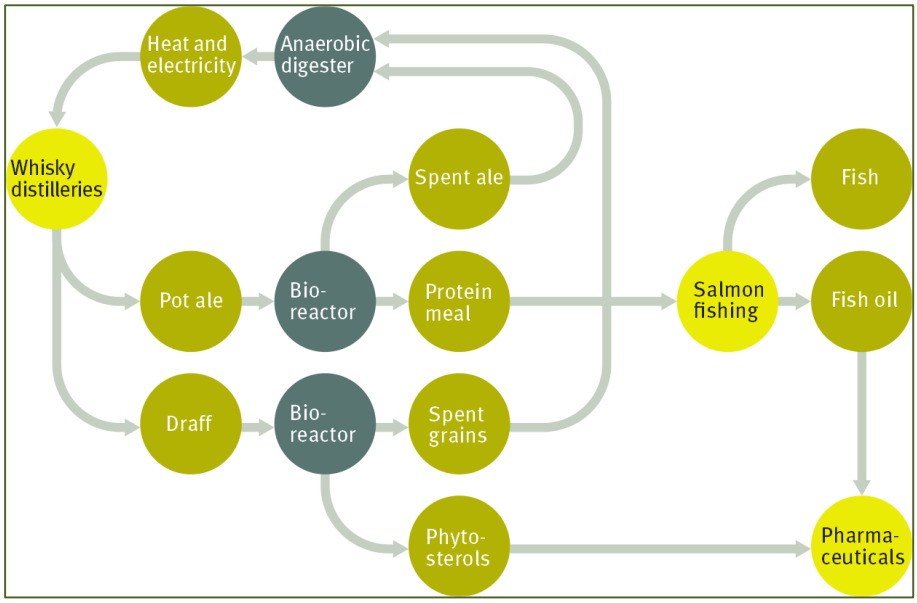

Figure 4 illustrates how distillery by-products – or 'co-products' – (e.g.pot ale and draff) can be converted using industrial biotechnology processes into a range of higher value materials including biofuels, proteins, heat and electricity. Importantly, this example also illustrates how waste outputs from one sector can provide an input into other sectors, strengthening collaboration between the primary, food and drink manufacturing and chemical science industries.

There are now around 50 core industrial biotechnology companies in Scotland[26] which, with 10 supply chain companies, generate turnover of over £200 million pa. By 2025 the sector aims to grow to over 80 companies, employing over 2,500 and generating over £900 million turnover pa. The European Commission also forecasts that the bio-based share of all chemical sales will rise from 12.3% to 22% between 2015 and 2020[27]. This is expected to be driven by a strong demand to substitute fossil-fuel sources for bio-based products including 'second generation' biofuels and 'renewable chemicals', produced from wastes/by-products rather than from crops.

Key challenges to securing such growth in the bioeconomy include the need to change existing practices to secure sufficiently high-volume, consistent and pure supplies of bio-feedstocks to make them economically viable. For example, much of Scotland's distillery co-products are already used by the agricultural industry as cattle feed and diverting these into higher value alternative uses such as high-value chemicals and biofuels could lead to additional costs for farmers to secure alternative feedstock.

Awareness of potential opportunities for creating value from current biological/chemical waste and/or low value products is now growing, supported by greater cross-sectoral collaboration. Recent initiatives,

[25] *Green Alliance in partnership with the Scottish Council for Development and Industry (2015) Circular Economy Scotland*
[26] *Frontline Consultants (2015) Economic Impact of Industrial Biotechnology in Scotland*
[27] *http://ec.europa.eu/growth/sectors/biotechnology/bio-based-products/index_en.htm*

particularly Scotland's industry-led National Plan for Industrial Biotechnology[28], the Biorefinery Roadmap and the Industrial Biotechnology Innovation Centre, are driving technology development and innovation to address these opportunities.

VII How should public policy implementation best address the opportunities?

As noted above, while circular business practices are already commonplace in certain sectors, patterns of adoption across the economy vary considerably owing to differing industry drivers, cost pressures and receptiveness to innovation. It is clear that Scotland – and other economies – are still at the early stages of a journey that will take many years.

The role of the public sector is to create an enabling policy framework, underpinned by a clear and consistent direction of travel that supports the necessary changes that are required to take place. Building on the *Zero Waste Plan* (2010) and *Safeguarding Scotland's Resources programme* (2013), the Scottish Government has now recognised the potential of the circular economy in *Scotland's Economic Strategy* (2015) as a wider policy goal that demonstrates benefits to business, communities as well as the environment.

The forthcoming consultation document on Scotland's circular economy programme includes a range of new proposals which form part of a long-term policy framework.

Design:

- support designers to design products for longer lifetimes, able to be disassembled, repaired and eventually recycled (since 80% of a product's environmental impact is effectively 'locked in' at the design stage);
- help companies to adopt new business models that allow them to retain ownership of valuable products and materials (eg product leasing, servicing and remanufacturing).

Reuse, repair and remanufacture:

- support more companies to adopt remanufacturing processes for defective and obsolete products;
- build acceptance of remanufactured products among consumers, and use public procurement processes to grow remanufacturing in Scotland;
- make it easier for consumers and businesses to repair damaged products by, for example, introducing a comprehensive repair-finding service and making technical manuals more easily available.

[28] *Chemical Sciences Scotland & Life Sciences Scotland (2015) National Plan for Biotechnology – Towards a cleaner, greener 2025*

Recycling (material recovery):

- improve recycling rates and ensure recycling services are more consistent across Scotland;
- improve the quality of recyclate (recovered recycled materials) by reducing levels of contamination in collection systems and attracting investment in materials reprocessing facilities.

Recovering value from biological resources:

- support company innovation and commercialisation to address technical barriers to the processing of bio-wastes into higher-value materials;
- develop better intelligence on material flows and stocks within and across sectors to support increased anaerobic digestion, composting and bio-refining.

Raising awareness of circular economy opportunities among companies and encouraging cross-sectoral collaboration are also taking place. One specific proposal is to develop a new *Scottish Circular Economy Network* to support greater collaboration and sharing of best practice. In addition, organisations such as Scotland's Innovation Centres, the Scottish Institute for Remanufacturing and the various Industry Leadership Groups of Scotland's key sectors also have important roles to play.

VIII The importance of building a robust evidence base

An important step in establishing the circular economy as a policy priority and communicating its significance is to identify the scale and nature of the economic opportunities. To date, key issues relate to definitions, data availability/gaps and methodologies.

First, defining the circular economy is difficult and not easily captured by official statistics. It is a concept that relates to businesses, markets and sectors across the whole economy, and cannot be categorised within one particular 'sector'. In effect, we are interested in recording the uptake of circular business practices such as the 3 R's (reuse, repair and remanufacturing) or the adoption of particular business models. Research to date at the EU and Scottish level has had to reply on 'bottom up' perspectives by identifying existing examples and extrapolating their impacts at higher sectoral or national economy levels.

Second, there are opportunities to strengthen intelligence on flows of materials such as plastics, textiles and paper. It is vital to establish more reliable and better quality data (often held by companies) on the consumption and flows of these materials. The mandatory introduction of the electronic waste transfer documentation system ("edoc") now proposed by the Scottish Government will help in this regard.

Better intelligence will also help provide greater certainty for local authorities, the waste management sector and investors more generally, allowing them to make clearer decisions on alternative uses of such materials. The Scottish Materials Brokerage Service is now being established to better match materials supply and demand and create stronger markets for materials trading in Scotland. This should

enable a greater security of supply to meet the economies of scale needed to make reprocessing more commercially viable for many materials in Scotland.

A third weakness in the evidence base relates to the methodologies used to assess the scale and nature of the circular economy. In Scotland as elsewhere, more robust assumptions and standardised methodologies are required that can withstand scrutiny. On all of these issues highlighted there are significant opportunities for closer collaboration between public agencies and researchers in Scotland. In particular, public agencies are keen to help develop greater capacity among the research community to support the further development of a circular economy in Scotland.

XI Conclusions

The vision of a circular economy in which nothing is wasted and everything is a resource is as exciting as it is challenging. In this vision, the economic system – or at least its material aspects – works more like an interconnected natural ecosystem that is geared towards maximum recovery of available resources, rather than a series of disconnected market places.

However, some may question the active promotion of such a policy approach by the Scottish Government, arguing that resource scarcity will lead to efficient adjustments of practices through market mechanisms, without the need for public sector intervention. This is a salutary “market failure” challenge and needs to be taken seriously by policy makers. However, the nature of the challenges outlined above (for example, engineering system-wide change and investing in long-term infrastructure needs) suggests that to make the circular economy a reality will require sustained supra-market co-ordination and a long-term public policy commitment by government that markets alone are not able or may not be willing to provide.

The evidence of the broad benefits of a circular approach is clear, both at a global and a Scottish scale. However, there is still a need for further, in-depth research on where the greatest opportunities lie and how they can best be realised in order to translate the vision into reality. Also required are more relevant statistics to track progress together with more consistent, economy-wide methodologies to be able to accurately assess the opportunities.

With its circular economy proposals, the Scottish Government is taking a big step towards realising its overarching Purpose of making economic growth truly sustainable. Though true circularity is not achievable in the short term, countries are able to learn from each other as their visions become reality. Given the interdependent strands of the circularity framework, success will depend on strong partnerships between Government, public sector partners and crucially, the private sector.

References

Braungart M. & McDonough W. (2002) *Cradle to cradle: Remaking the way we make things*. North Point Press
Chatham House (2012) *A Global Redesign? Shaping the Circular Economy*
https://www.chathamhouse.org/sites/files/chathamhouse/public/Research/Energy,%20Environment%20and%20Development/bp0312_preston.pdf

Chemical Sciences Scotland & Life Sciences Scotland (2015) *National Plan for Biotechnology – Towards a cleaner, greener 2025*
http://www.sdi.co.uk/~/media/sdi_2013/chemical%20sciences/national_plan_for_industrial_biotechnolog.pdf

Club of Rome (2015) *The circular economy and benefits for society: Swedish case study shows jobs and climate as clear winners* http://www.clubofrome.org/cms/wp-content/uploads/2015/04/Final-version-Swedish-Study-13-04-15-till-tryck-ny.pdf

European Commission (2014) *Towards a circular economy: A zero waste programme for Europe*

Ellen MacArthur Foundation (2012) Towards the circular economy – economic and business rationale for an accelerated transition

Ellen MacArthur Foundation (2013) Towards the circular economy – opportunities for the consumer goods sector

Ellen MacArthur Foundation, Scottish Enterprise and Zero Waste Scotland (2013) *Scotland and the circular economy: A preliminary examination of the opportunities for a circular economy in Scotland*
http://www.zerowastescotland.org.uk/content/scotland-and-circular-economy-report

Ellen MacArthur Foundation (2015) *Delivering the circular economy: A toolkit for policymakers*
http://www.ellenmacarthurfoundation.org/books-and-reports

Frontline Consultants (2015) *Economic Impact of Industrial Biotechnology in Scotland*. Research commissioned by Scottish Enterprise

Frosch, R.A. & Gallopoulos, N.E. (1989) *Strategies for Manufacturing*. Scientific American 261 (3): 144–152.

Green Alliance in partnership with the Scottish Council for Development and Industry (2015) *Circular Economy Scotland* http://www.green-alliance.org.uk/circular-economyscotland.php

Institute for Public Policy Research (2014) *The wasteline: Redefining 'waste' and improving resource management policy* http://www.ippr.org/read/the-wasteline-redefining-waste-and-improving-resource-management-policy#

McKinsey Center for Business and Environment & Ellen MacArthur Foundation (2015) *Growth within: A circular economy vision for a competitive Europe*
http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/sustainability/2015%20circular%20growth%20report/growth_within-a_circular_economy_vision_for_a_competitive_europe%20(1).ashx

Scottish Government (2015) *Scotland's Economic Strategy* http://www.gov.scot/Publications/2015/03/5984

Scottish Government and partners (2015) *Remanufacturing Study*
http://www.zerowastescotland.org.uk/RemanufacturingReport

Scottish Government and partners (2015) *Sector Study – Beer, Whisky and Fish*
http://www.zerowastescotland.org.uk/BeerWhiskyFish

Scottish Government (2015) *Making things last: Consultation on creating a more circular economy in Scotland* *http://www.gov.scot/Resource/0048/00483940.pdf*

Stahel, W. (2010) *The performance economy*. MacMillan

The Netherlands Organisation for Applied Scientific Research (TNO) (2013) *Opportunities for a circular economy in the Netherlands* http://www.government.nl/documents-and-publications/reports/2013/10/04/opportunities-for-a-circular-economy-in-the-netherlands.html

UN Global Compact (2013) *Accenture CEO Survey 2013*

World Economic Forum (2014) *Towards the Circular Economy: Accelerating the scale-up across global supply chains.* Prepared in collaboration with Ellen MacArthur Foundation and McKinsey & Company
http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf

Zero Waste Scotland (2015) *The Carbon Impacts of the Circular Economy*
http://www.zerowastescotland.org.uk/CarbonImpactsOfTheCircularEconomy

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