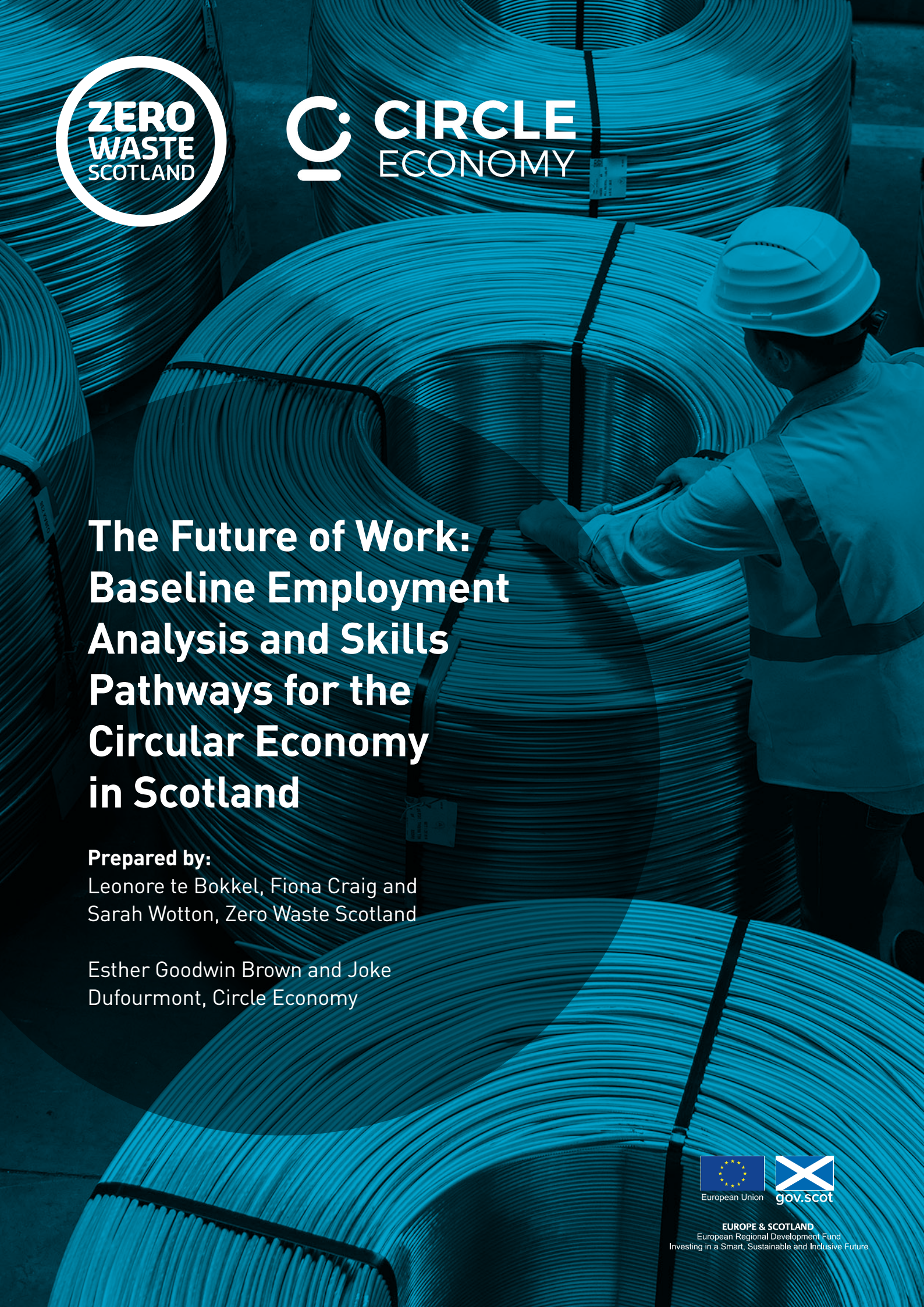

The Future of Work: Baseline Employment Analysis and Skills Pathways for the Circular Economy in Scotland

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European Regional Development Fund
Investing in a Smart, Sustainable and Inclusive Future

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Zero Waste Scotland exists to lead Scotland to use products and resources responsibly, focusing on where we can have the greatest impact on climate change. Using evidence and insight, our goal is to inform policy, and motivate individuals and businesses to embrace the environmental, economic, and social benefits of a circular economy. We are a not-for-profit environmental organisation, funded by the Scottish Government and European Regional Development Fund.

Circle Economy is an impact organisation that connects and empowers a global community to create the conditions for a transformation towards the circular economy. Its mission is to accelerate the transition to the circular economy through practical and scalable insights and solutions that address humanity's greatest challenges. The Circular Jobs Initiative is a knowledge centre within Circle Economy that aims to ensure the transition to the circular economy is positive for work and workers.

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Forewords

Iain Gulland
Zero Waste Scotland

As Scotland moves towards the new green recovery, the future world of work looks very different. Like the climate emergency, COVID-19 has brought devastation on a local, national and global scale. But the pandemic has also shown that it is feasible to adopt more sustainable ways of working which will ensure that the economy and the environment recover in harmony to overcome both crises at once. We need to keep on doing things differently.

Many service industry organisations, including Zero Waste Scotland, are making radical operational changes to survive and thrive, such as switching to permanent homeworking to make significant savings in carbon emissions and cash.

The unprecedented challenges and the need for less wasteful business practices also bring diverse, invaluable and interesting opportunities for job creation and a wide range of new business models and ventures.

To turn those chances into real jobs and skill-sets we need to stop wasting resources through our traditional economic model of 'make, take and throw' and switch to a national circular economy – keeping goods and materials in a 'loop' of use maximising value and minimising waste and the damaging emissions which that creates.

We know that we have made progress since the Scottish Government published its landmark 2016 circular economy strategy, entitled Making Things Last, to help spell out the environmental, economic and social benefits of doing just that.

However, around four fifths of Scotland's carbon footprint is still caused by the production, consumption and, too often, waste of goods, services and materials. This remains the single greatest cause of the climate crisis. This needs to stop if we are to meet the Scottish Government's aim of ending our contribution to climate change by 2045.

Until now we have not had clear data on the scale of the existing circular economy in Scotland – or the priority sectors likely to bring the biggest circular gains in the months and years ahead as we work together to reach net-zero.

This report provides, for the first time, a baseline analysis which is vital for increasing our understanding to drive progress forward. And while it was planned in a pre-COVID world it could not be more timely. It found that nearly one in ten Scottish jobs nationally and regionally is already related to the circular economy. Many of these posts are in core circular economy areas like repairing and recycling goods, while substantial numbers are in design and technology. However, circular jobs and activities also varied by region, suggesting that emerging green recovery policies must take account of local needs.

One in ten is significant, but we need to reach ten out of ten.

The report also highlights key opportunities to make that leap by pioneering exciting new roles and skills across a range of levels in three key priority areas of work. These were the bioeconomy, capital projects – such as decommissioning Scotland's oil rigs and wind farms – and construction. Key prospects include helping the traditional workforce to diversify, particularly in rural economies where agritourism and bioenergy promise significant gains.

Potential 21st century roles include material scouts and urban miners who will be needed to find local sustainable sources of materials so Scotland can literally build back better.

The world of work is changing. It needs to keep changing to bring the environmental, economic and social change we need from the green recovery. We need to carry on doing more differently.

Mark Mitchell
Fraser of Allander Institute

The economy and the environment are inseparable. At its core, economic activity relies on the natural environment and people. It also determines how, and the extent to which, each of these are utilised.

The majority of traditional economic activity is "straight-line", however, in that it capitalises on resources once, or in only one way. Circular economic activity on the other hand utilises their full potential, at the same time reducing waste and offering new opportunities for work.

In 2019 the environmental and climate emergency was thrust into the policy debate more so than ever, and the recent outbreak of Covid-19 and the resultant lockdown have left Scotland facing unprecedented social and economic challenges.

As a result, recent focus of economic policy has been on supporting existing jobs and businesses. There is, however, a need for discussion that maintains focus on the long-term economic vision for Scotland, and the broader social, economic and environmental challenges of the 21st century.

This report does that by bringing together discussion on environmental policy and a more sustainable economic model for the future as Scotland emerges from the current crisis and into a post-Brexit world.

By focussing on both existing and future opportunities to reduce waste from the economy, it offers a forward-looking perspective on how it can in fact be "built back better" in a more sustainable way.

It is the first research into the extent of circular economic activity in Scotland and how it can be expanded. It also offers channels through which jobs can be created and skills and expertise can be developed to capitalise on the opportunities a more circular economic model would create.

The research of this report is of course timely given Scotland is in the midst of a recession that has reshaped the world of work and sparked discussion of a green recovery. Importantly, however, the evidence it provides is not simply a response to this discussion, but rather an important contribution to the wider debate on the economy, people, and environment - perhaps the eminent policy challenge of the coming decades.

Iain Gulland, Zero Waste Scotland

Mark Mitchell, Fraser of Allander Institute

Executive Summary

The year 2020 has brought multiple challenges for Scotland's economy, environment and society, from the impending conclusion of the Brexit transition period at the end of the year to the unexpected lockdown caused by the COVID-19 pandemic.

However, the climate emergency declared by the Scottish Government in 2019 remains the greatest of these crises. Whether Scotland recovers and prospers depends on whether the nation can deliver the economic change now needed while simultaneously prioritising the needs of our people and the planet.

Meeting the environmental, economic and social aims of Scotland's new wellbeing economy, now central to the Scottish Government's emerging green recovery, means embracing the circular economy nationwide. That in turn means that overcoming these unprecedented problems also presents significant opportunities to reap the financial and societal rewards of investing in the infrastructure and capacity needed. The circular economy is key to reducing waste and the related emissions driving the climate crisis; it is also key to creating much-needed sustainable jobs and businesses by turning waste into value to support a stronger, fairer society.

This report is the first baseline analysis of circular economy jobs across Scotland. In addition to this our analysis identified a wide-range of circular roles and skills needed for powering a national circular economy. We have used this to outline future pathways in three priority value chains[1] - construction, the bioeconomy and capital equipment, such as decommissioning energy infrastructure from oil rigs to wind turbines.

We found that nearly one in ten jobs (8.1%) in Scotland are related to the circular economy. This is a significant number showing both the progress made nationally – and also the huge step-change we must still make to create the national circular economy we urgently need now to ensure we end our nation's contribution to the climate crisis by 2045.

The baseline analysis found that the share of circular jobs per region ranges from 7-9.8%. In all regions other than Eastern Scotland, the circular economy generates the most jobs in enabling circular sectors and the fewest in core circular sectors[2]. While no significant regional differences within Scotland have been found, the composition of circular jobs - meaning the circular activities these jobs are related to - varies.

- In the **Highlands & Islands**, 16,689 jobs are related to the circular economy (7% of all jobs in the region). Most circular jobs (47.1%) in the region are generated indirectly by demand for core products and services by sectors including manufacturing, wholesale and retail.

- In **North East Scotland**, 28,110 jobs are related to the circular economy (9.8% of all jobs in the region). It has the highest percentage of circular jobs in design compared to all other regions.

- In the **East of Scotland**, 80,447 jobs are related to the circular economy (8.4% of all jobs in the region). Unlike other regions, most circular jobs are generated by enabling circular sectors, namely in relation to design and digital technology.

- In **South West Scotland**, 82,181 jobs are related to the circular economy (7.7% of all jobs in the region). It has the highest number of core circular jobs (15,464) compared to other regions in Scotland.

[1] The term value chain is used in this report to refer to the circular activities within bioeconomy, capital equipment, and construction, as they do not fit within traditional sector descriptions. The value chain perspective helps to capture different activities and stages associated with materials and products within their lifecycle.
[2] Enabling circular sectors, indirectly circular sectors and core circular sectors are defined by the DISRUPT Framework found in Part 1 of this report.

For each value chain, detailed insights into skills pathways were generated. From across the value chains, the common skills and training requirements identified include:

- **Strengthen transferable and digital skills:** Many circular economy strategies require a digitally-enabled workforce. As industries shift and new markets open up through advances in material science and technologies, it will be increasingly important that workers have transferable skills, like adaptability, to enable them to move between industries as they evolve with the transition.
- **Develop holistic thinking across the workforce:** Integrate lifecycle and systems thinking across interdisciplinary, vocational, professional and higher education courses in order to promote understanding of the dynamics, roles, responsibilities and value associated with the circular economy.
- **Promote the circular economy as a career destination:** Integrate understanding and skills for the circular economy into all curricula and sectors, so the circular economy becomes synonymous with our economy and there are clearer pathways into roles and sectors that contribute to it.
- **Integrate circularity into the existing skills landscape:** Align circular economy industry hubs with enterprise and skills agencies already developing support and manage the urban-rural divide to ensure inclusive opportunities for skills development across rural and urban communities.
- **Introduce innovative forms of learning and knowledge exchange:** Encourage closer collaboration between industry and education through innovation centres and demonstrator sites that can be visited by students, educators, employers and workers.
- **Harness skills for the energy transition:** Develop and implement skills pipelines to ensure the employment, environmental and economic opportunities associated with the energy transition can be fully exploited - particularly the largely untapped potential associated with reuse and remanufacture of infrastructure from the energy sector.

Potential pioneering 21st century roles such as material scouts and urban miners are needed to find local sustainable sources of construction materials, and the traditional workforce needs to be adapted by, for example, diversifying rural economies to include agritourism and bioenergy production.

Making roles like this part of the 'new normal' in Scotland will help to create a country which is more resilient to pandemics, recessions and supply chain volatility. These new job prospects can also help reduce existing social inequalities exacerbated by COVID-19 by redistributing employment opportunities and providing more widespread access to essential goods and services that meet Scotland's environmental and zero-carbon ambitions.

Scotland is already a world leader in low carbon energy thanks to our ambitious renewable energy policies. This report, produced using a standardised and replicable method for quantifying circular economy jobs developed by fellow experts in the Netherlands, provides proof that Scotland's circular economy is currently on a par with others in Europe. As more countries across the globe increasingly switch to circularity, we must do much more to stay competitive.

This report provides information and ideas to help a range of Scottish agencies including governments, enterprise organisations, businesses and universities to collaborate to create a new circular, sustainable workforce that Scotland needs to truly build back better through the new green recovery.

Introduction

Along with the rest of our global community, Scotland is facing a challenging time as society and the economy are under increasing pressure from the COVID-19 pandemic, along with the climate emergency [1], environmental degradation, biodiversity loss, finite resources, and a range of other uncertainties. However, it's also an opportunity for change.

The circular economy is an economic and industrial development model based on the principles of reducing consumption of natural resources, designing out waste and pollution, keeping products and materials in use for as long as possible and extracting maximum value from them whilst in use, and recycling the materials at the end of each service life. It is a restorative and regenerative system underpinned by innovative technologies and integrated services, strengthened local and regional supply chains, and decarbonisation of energy supply.

Reshoring economic activity to benefit from the carbon competitiveness of Scotland's green electricity generation, and the introduction of new design strategies, production processes and business models can create environmental and economic wins. These opportunities also change the world of work with potentially significant implications for the Scottish labour market.

Previous research has demonstrated the job creation potential of the circular economy [2,3,4,5,6]. But while a circular transition is expected to create new opportunities for the labour market, other jobs may be restructured, redefined, or lost, particularly in carbon-intensive sectors. Innovation, investment and policy action are all needed to support changes that maximise the economic and social benefits of the transition to the circular economy. Workers' rights need to be continuously assessed and safeguarded as sectors shift and the workforce needs to be upskilled and reskilled to build capacity and minimise job loss.

While fundamentally important if we are to realise the ambitions set out in the Scottish Circular Economy Strategy Making Things Last [7], our current understanding of circular economy jobs is limited, and the skills implications of the transition have received little attention in international literature. Developing an understanding of the roles and skills required for a more circular future and the skills gaps which need to be addressed is crucial to enable a just transition that "make(s) all possible efforts to create decent, fair and high-value work, in a way which does not negatively affect the current workforce and overall economy" [8]. Without it, businesses may struggle to find the right talent, skill-sets and leadership to take advantage of opportunities the circular economy presents.

This report, by Zero Waste Scotland in collaboration with the Dutch impact organisation Circle Economy, represents the first ever national assessment of existing and potential circular jobs and skills. It aims to inform debate and action on the nationwide transition to a circular economy for the Scottish labour market by answering four key questions:

1. What are circular jobs, roles and skills and how do they differ from 'traditional' ones?
2. How many jobs in Scotland are already associated with the circular economy?
3. Which circular activities provide future opportunities for the Scottish workforce?
4. What skills do educators, employers and workers need to develop to do the tasks and roles that drive a national circular economy?

Part 1 of this report provides a definition of circular jobs, and insights into the nature and number of jobs associated with the Scottish circular economy and their geographical distribution. This baseline analysis is produced using a standardised and replicable methodology developed by Circle Economy and Erasmus Happiness Economics Research Organization (EHERO). Results of the baseline analysis are also displayed in an online Circular Jobs Monitor, which gathers, displays, and tracks the number and range of jobs that are part of the circular economy around the world.

Part 2 of the report explores different types of circular jobs, roles and skills associated with opportunity areas in three value chains – construction, bioeconomy and capital equipment, such as decommissioning Scotland's oil rigs and wind turbines and providing products and services to lease instead of own.

Part 1: Circular Economy Jobs in Scotland

Jobs in the Circular Economy

The core strategies of the circular economy, used to keep materials in circulation for as long as possible at their highest value, including reuse, repair, remanufacture and recycling, are labour and skill intensive.

They require more hands and more complex processes, including for recycling, reverse logistics, resource sorting and the cleaning of components in the refurbishment of products, than traditional, linear processes like mining, manufacturing and landfilling [9,10].

Alongside these labour-intensive core strategies, making the circular economy a reality at scale also requires investment and employment in enabling strategies, including in design and digital technologies as well as areas which indirectly support the circular economy, including education, marketing and procurement [11].

The definition of circular jobs used in this report takes into account a broader number of sectors and jobs generated by cross-sector interactions than previous attempts at defining circular economy employment, which used more one-dimensional sector-based approaches [6,12].

Even so, this report may not fully represent all jobs and sectors contributing to the circular economy in Scotland given the challenges related to the different ways that circular activities and businesses are interpreted and classified and where, for example, circular activities currently account for only a small part of a role or business.

The definition of circular jobs used in this report differs from the concept of green jobs, defined by the International Labour Organization (ILO) as jobs in "businesses that produce goods and provide services that benefit the environment" [13]. This is because the circular economy brings economic and social benefits as well as environmental rewards through business models focused on greater durability of products, innovation, industrial strategy and climate objectives [14,15].

The ILO [16] suggests that the extent to which jobs roles will need to be adapted and upskilled to work in greener ways increases with occupation skill-level. For example, practical workers may require minor behavioural adaptations that can largely be taught on the job. Whereas most newly emerging roles are generated within highly-skilled occupations, through the demand for specialist skills which require higher levels of education or longer-term upskilling programmes. A similar pattern of change may sometimes apply to the skills transition required in areas of the circular economy. As well as requiring a general upskilling as a result of task diversification and advances in technology, the circular economy also calls for a fundamental shift in mindsets at all levels of the workforce. Public and private leadership is required to encourage systemic thinking amongst workers across the full range of sectors that contribute to the circular economy.

Jobs in the Circular Economy

The circular labour market is comprised of all kinds of jobs in different sectors, ranging from manufacturing and creative industries to waste and resource management. Jobs in the circular economy, shortly 'circular jobs', are all jobs that contribute to one of the strategies of the DISRUPT framework.

- **Core circular jobs.** These jobs ensure that raw material cycles are closed and thus form the core of the circular economy. They include jobs in renewable energy, repair and waste and resource management sectors. Examples of core circular jobs are displayed in light blue in the framework on the right.
- **Enabling circular jobs.** These jobs enable the acceleration and upscaling of core circular activities and thus form the supporting shell of the circular economy. They include jobs in leasing, engineering and digital technology - albeit only those that actually contribute to circularity. Examples of enabling circular jobs are displayed in dark blue in the framework on the right.
- **Indirectly circular jobs.** These jobs provide services to the primary circular activities above and thus form the activities that indirectly uphold the circular economy. They include, for example, jobs in education, logistics and the public sector. Examples of indirectly circular jobs are displayed in grey in the framework on the right.

D — **DESIGN** FOR THE FUTURE

Adopt a systemic perspective during the design process, to employ the right materials for appropriate lifetime and extended future use.

Circular equipment engineers design products to enable parts and resource recovery after the product's use phase. They excel in complex problem solving on a technical level designs for the future.

I — **INCORPORATE** DIGITAL TECHNOLOGY

Track and optimise resource use and strengthen connections between supply-chain actors through digital, online platforms and technologies.

Building information managers maintain data on construction components so as to keep track of these physical assets. They understand how to integrate and interpret virtual information management systems.

S — **SUSTAIN & PRESERVE** WHAT'S ALREADY THERE

While resources are in-use, maintain, repair and upgrade them to maximise their lifetime and give them a second life through take back strategies when applicable.

Repair technicians repair appliances, machines or vehicles. They possess strong technical and manual skills which can be acquired through a formal and informal education and training.

R — **RETHINK** THE BUSINESS MODEL

Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.

Demand planners oversee supply and demand to make refurbishment a profitable business model. This role requires logical thinking and reasoning.

U — **USE** WASTE AS A RESOURCE

Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.

Process operators sort waste for sellable products, for example to produce livestock feed made from waste flows. Although classed as practical-skill work, knowledge of the quality of incoming raw materials is crucial.

P — **PRIORITISE** REGENERATIVE RESOURCES

Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.

Agronomic advisors support healthy soil nourishment with organic fertiliser from composted manure and crop remnants. They combine strong interpersonal skills with ecological knowledge.

T — **TEAM UP** TO CREATE JOINT VALUE

Work together throughout the supply chain, internally within the organisation and with the public sector to increase transparency and create shared value.

Procurement professionals stimulate the demand for secondary materials and discern and connect new suppliers in order to do so. This profile points to the need for entrepreneurial, interpersonal skills.

Indirectly circular jobs

These jobs provide services to the primary circular activities above and thus form the activities that indirectly uphold the circular economy.

The **courier** brings packages to and from consumers as part of a reverse logistics scheme that enable new business models.

The **teacher** transfers knowledge and skills to the (future) workforce so as to equip workers with the skills for all circular economy strategies.

Baseline Employment Analysis

Monitoring employment provides an indication of circular activity in a geography. It can be used to map the level at which different circular economy strategies have been developed and the existing expertise in the geography. In order to further tap into the potential of the circular economy for the labour market, it is vital to understand how many and which jobs are already contributing to the circular economy in a given geography.

The methodology applied to calculate the number of circular jobs in Scotland follows a sector-focused approach. The data is organised following the UK Standard Industrial Classification (SIC) 2007, a standardised system employed in the UK [17]. Based on the seven key elements framework (DISRUPT[3]) outlined on pages 12 and 13 [18], almost 2,000 sectors are differentiated and classified as core, enabling or indirectly circular.

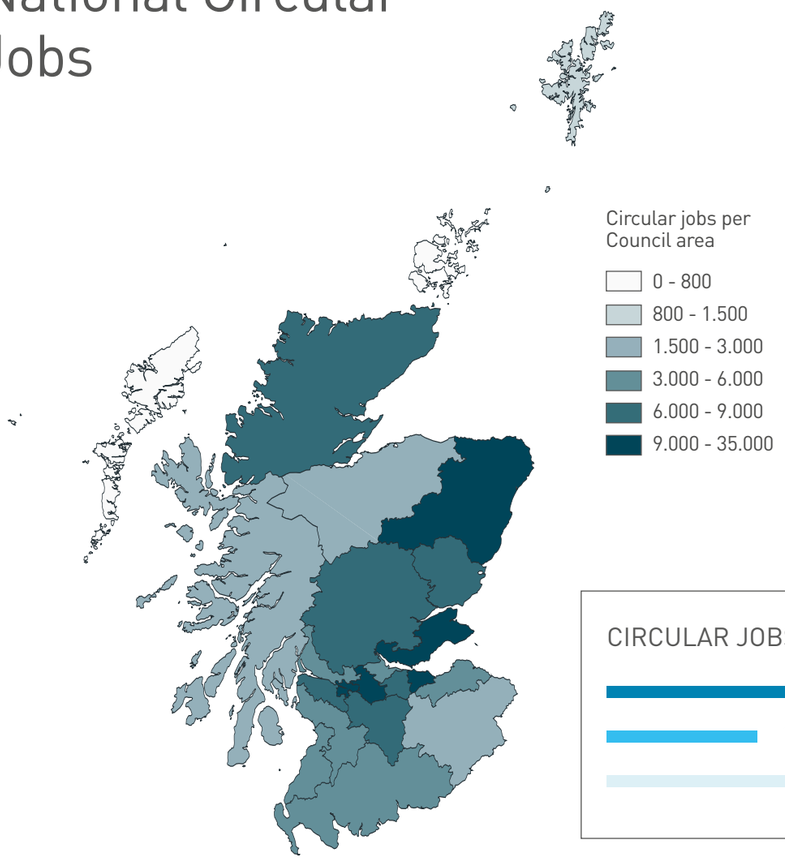
CIRCULAR JOB	ECONOMIC SECTOR	CIRCULAR ECONOMY ELEMENT	EXAMPLE SECTORS AND ACTIVITIES
DIRECT CIRCULAR JOBS	**CORE SECTORS**	Sustain and Preserve What's Already There Use Waste as a Resource Prioritise Regenerative Resources	Repair Services Recycling Renewable Energy
	ENABLING SECTOR	Design for the Future Incorporate Digital Technology Rethink the Business Model Team up to Create Joint Value	Industrial Design and Architecture Digital Technology Renting or Leasing Activities Professional and Networking Associations
INDIRECTLY CIRCULAR JOBS	**INDIRECTLY CIRCULAR SECTORS**		Education Government Services Professional Services

Table 1: An indication of how sectors are mapped to the DISRUPT Framework

This baseline analysis utilised 2016 Business Register and Employment Survey (BRES) employment data [19]. The regional results are broken down in this report and displayed on the Circular Jobs Monitor according to the four regions in Eurostat's Nomenclature of Territorial Units for Statistics (NUTS) 2013 [20]. For a full explanation of the method used, including its advantages and limitations, please refer to the Annex.

[3] In an effort to define a common language for the circular economy, Circle Economy has mapped the various terms and definitions used by over 20 organisations. After interpreting and grouping these various terms, seven key elements of the DISRUPT framework emerged that defined the majority of terms linked to the circular economy.

National Circular Jobs



CIRCULAR JOBS

42% Enabling

19% Core

39% Indirectly

Nearly one in ten jobs in Scotland (8.1% or 207,427 jobs) are generated by the circular economy. This share of circular employment is broadly on par with other countries where similar analyses have been carried out, such as the Netherlands and Belgium [21].

These jobs are distributed across core circular sectors (18.7% or 38,784 jobs), enabling circular sectors (42.1% or 87,366 jobs), and indirectly circular sectors (39.2% or 81,277 jobs).

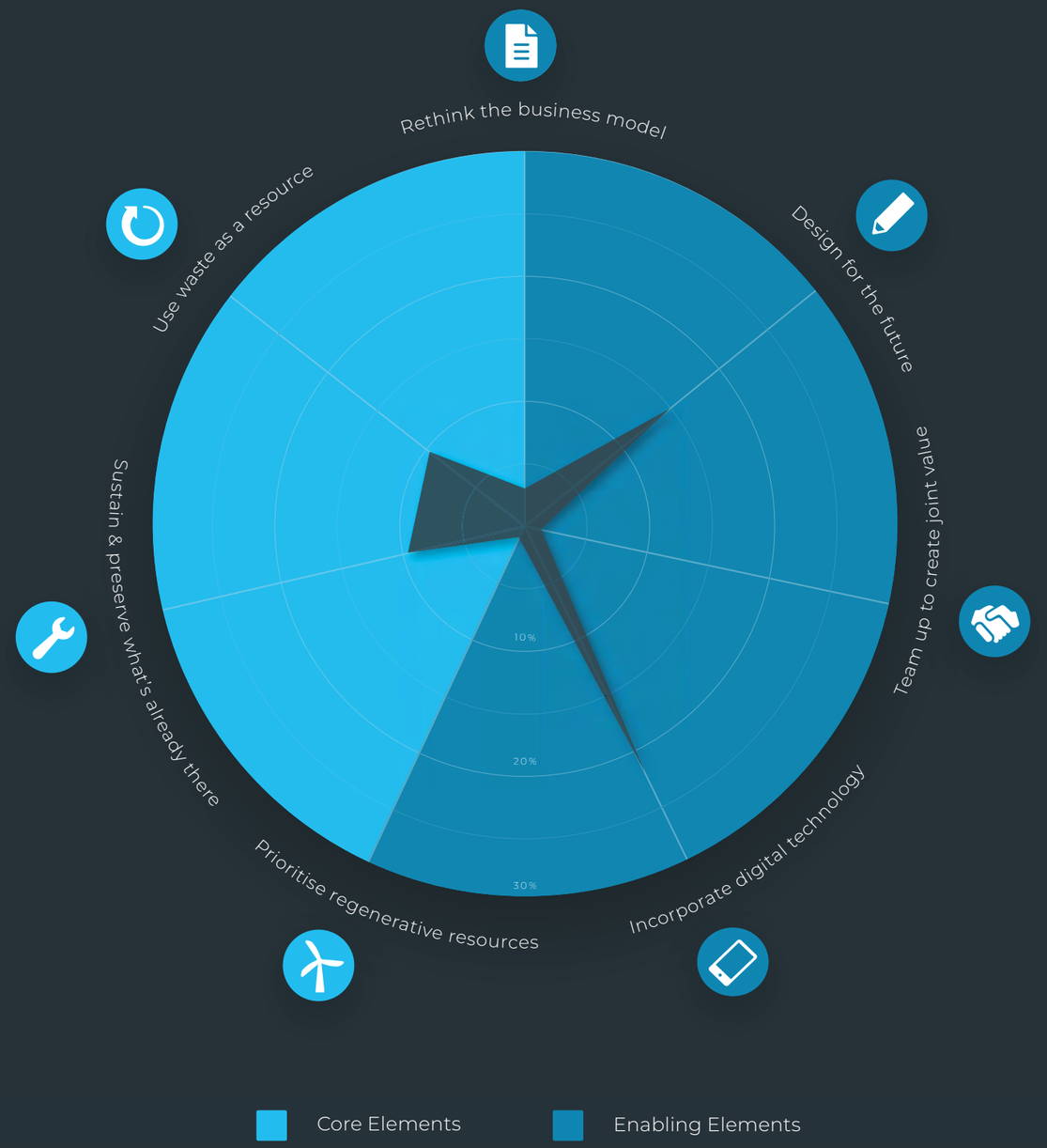
Core circular jobs relate to jobs in the repair, renewable energy and recycling sectors. The repair sector generates 18,395 core circular jobs (8.9% of all circular jobs), with the majority related to activities within the manufacturing industry (10,395 jobs). The initial baseline analysis has identified 17,360 core circular jobs in resource management. However, a closer analysis indicates that, of these, the recycling sector generates 14,807 core circular jobs (7.1% of all circular jobs)[4].

The production of renewable energy generates 4,854 core and indirectly circular jobs (2.3% of all circular jobs). This relatively low share of circular jobs may be due to the reliance on average UK data on renewable energy employment which does not capture inter-regional differences.

As is commonly found due to their role in servicing other sectors, the digital technology and design sectors generate a significant number of enabling jobs, together generating 76,131 jobs in Scotland (36.7% of all circular jobs).

[4] The number of circular jobs in the waste management sector has been corrected based on waste processing methods that are considered circular and those that are not, such as incineration and landfilling activities. See the Annex for the method behind these numbers. In addition, please note that while this adjustment has been performed on a national level, this could not be done on a regional level.

Direct Circular Jobs



Regional Circular Jobs

To further explore regional level differences in the range of circular jobs already present in Scotland, this analysis divided Scotland into four regions: Highlands & Islands; North Eastern Scotland; Eastern Scotland; and South Western Scotland. Results by Local Authority area can be found on the Circular Jobs Monitor.

In relative terms, there were no significant regional differences across Scotland in the share of circular jobs, which ranged from 7% to 9.8% in line with the national picture. In all regions other than Eastern Scotland, the circular economy generates the most jobs in enabling circular sectors and the fewest in core circular sectors.

In absolute terms, the most circular jobs are located in South Western Scotland and Eastern Scotland, together representing 78.4% of all circular jobs. However, in relative terms, all regions show a similar circular share of employment between 7% and 9.8%.

Regional variations in the circular economy are summarised below:

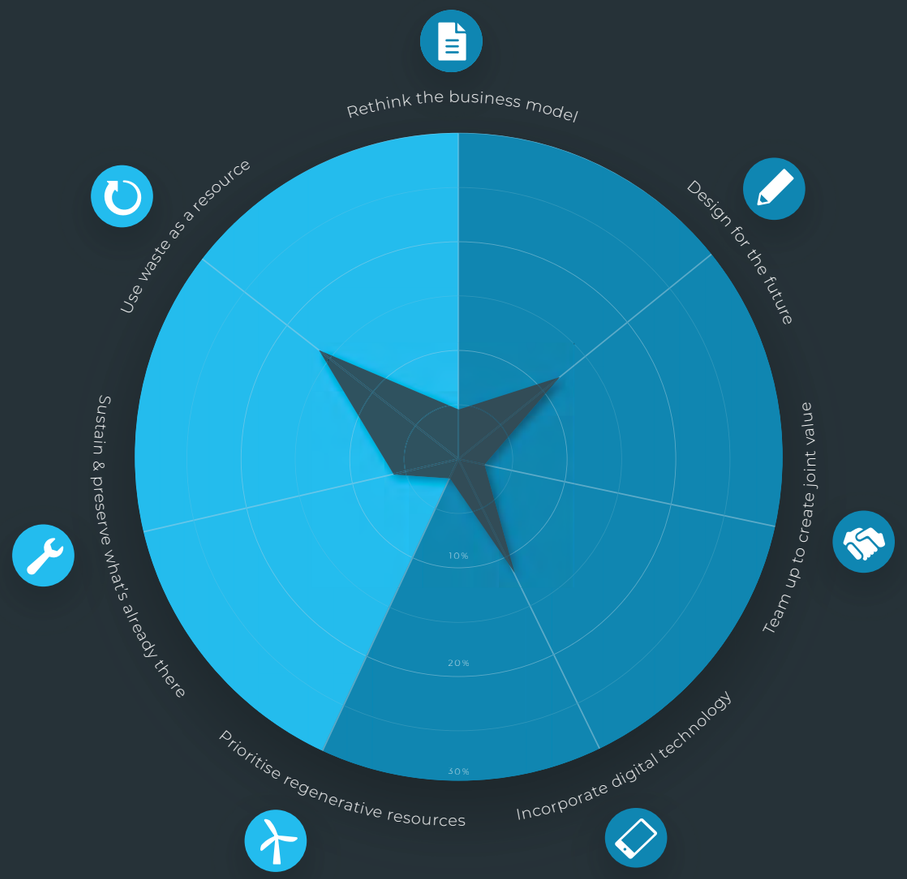
- In the Highlands & Islands, 16,689 jobs (7% of all jobs in the region) are related to the circular economy. Most circular jobs in this region (47.1%) are generated indirectly by demand for core products and services by sectors including manufacturing, wholesale and retail.
- In North Eastern Scotland, 28,110 jobs (9.8% of all jobs in the region) are related to the circular economy. This region has a higher percentage of circular jobs in design than any other Scottish region.
- In Eastern Scotland, 80,447 jobs (8.4% of all jobs in the region) are related to the circular economy. Unlike other regions, most circular jobs here are generated by enabling circular sectors, in design and digital technology.
- In South Western Scotland, 82,181 jobs (7.7% of all jobs in the region) are related to the circular economy. This region has more core circular jobs (15,464) than any other Scottish region.

Highlands & Islands

In total, 16,689 jobs in the region are related to the circular economy (7% of all jobs in the region). There are 3,919 core circular jobs, accounting for 23.5% of all circular jobs in the region. Of these, 2,675 are related to resource management[5] and 980 to the repair sector. Circular jobs in repair are mainly related to the repair of motor vehicles or the manufacturing sectors.

Some 4,904 jobs are generated in enabling circular sectors (29.4% of all circular jobs). In line with the national picture, a large proportion of the enabling jobs in the region are related to the design and technology sectors, which together account for 3,705 jobs, or 22.2% of all circular jobs in the region.

As with much of the rest of the country, most circular jobs are generated by sectors indirectly supporting the circular economy, accounting for 7,866 jobs (47.1% of all circular jobs in the region). These jobs are mainly generated through demand for core circular products or services by the healthcare and social work, wholesale and retail trade, repair of motor vehicles and motorcycles and manufacturing sectors.



[5] This includes jobs associated with both circular and non-circular activities in the resource management sector, as this could not be corrected on a regional level.

North Eastern Scotland

In total, 28,110 jobs in the region are related to the circular economy (9.8% of all jobs in the region).

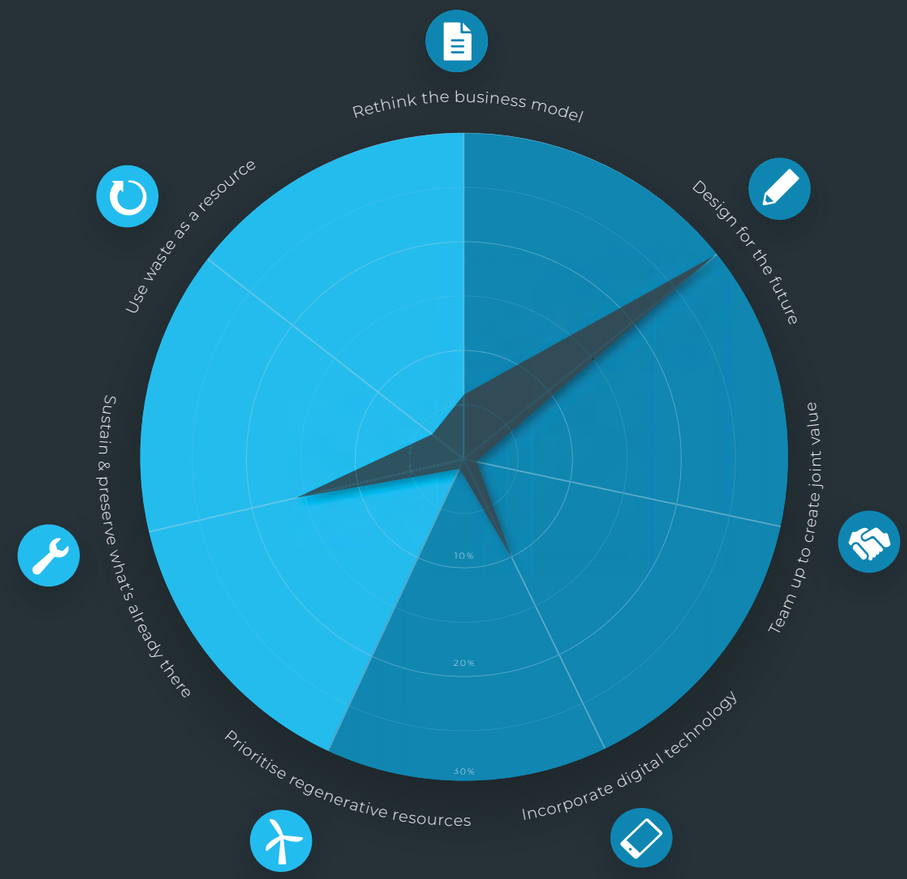
There are 5,638 core circular jobs (20.1% of all circular jobs in the region). Of these, 4,500 are related to the repair sector (16% of all circular jobs in the region).

Some 13,421 jobs are generated in enabling circular sectors (47.7% of all circular jobs). In line with the rest of the country, a large proportion of enabling jobs in the region are related to the design and digital technology sectors, which together account for 11,262 jobs or 40.1% of all circular jobs in the region.

In relative terms, North Eastern Scotland has the highest percentage of circular jobs in design compared to all other regions.

A further 1,781 of the enabling circular jobs in the region are related to circular business models, such as leasing, rental and sharing products as services to use instead of goods to own.

In line with the rest of Scotland, most circular jobs in the region are generated by sectors indirectly supporting the circular economy, accounting for 9,051 jobs (32.2% of all circular jobs). These jobs are mainly generated through demand for core circular products or services by mining, manufacturing, public administration[6], healthcare and social work[7].



[6] Public administration refers to the SIC code Public administration and defence.
[7] Healthcare and social work refers to the SIC code Human health and social work activities.

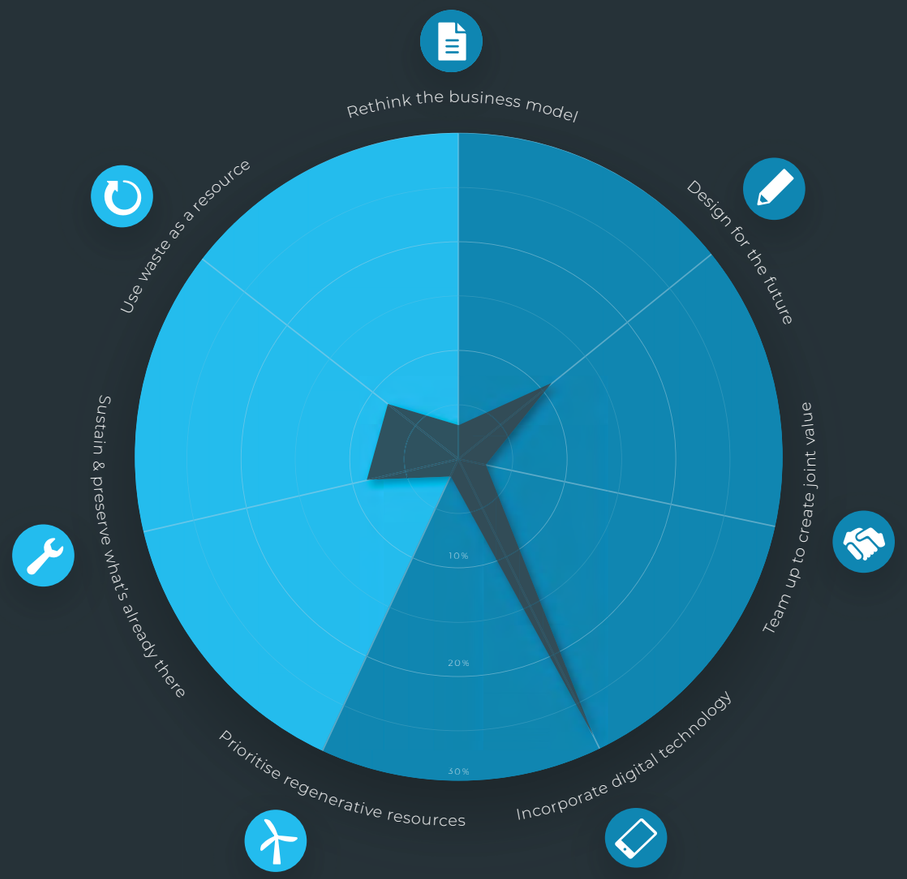
Eastern Scotland

In total, 80,447 jobs in the region are related to the circular economy (8.4% of all jobs in the region).

There are 13,763 core circular jobs, accounting for 17.1% of all circular jobs in the region. Of these, most relate to the resource management[8] and repair sectors, generating 12,220 jobs (15.2% of circular jobs in the region). The remaining 1,543 jobs are in the production and supply of renewable energy.

Unlike other Scottish regions, most circular jobs in Eastern Scotland are generated by enabling circular sectors (36,824 jobs and 45.8% of circular jobs in the region). The majority of these jobs are in the digital technology sector, which alone generates 22,893 circular jobs in the region.

Some 29,860 circular jobs are generated by sectors indirectly supporting the circular economy (37.1% of all circular jobs). These jobs are mainly generated through demand for core circular products or services through tourism, education, manufacturing, wholesale, retail, public administration, healthcare and social work.



[8] This includes jobs associated with both circular and non-circular activities in the resource management sector, as this could not be corrected on a regional level.

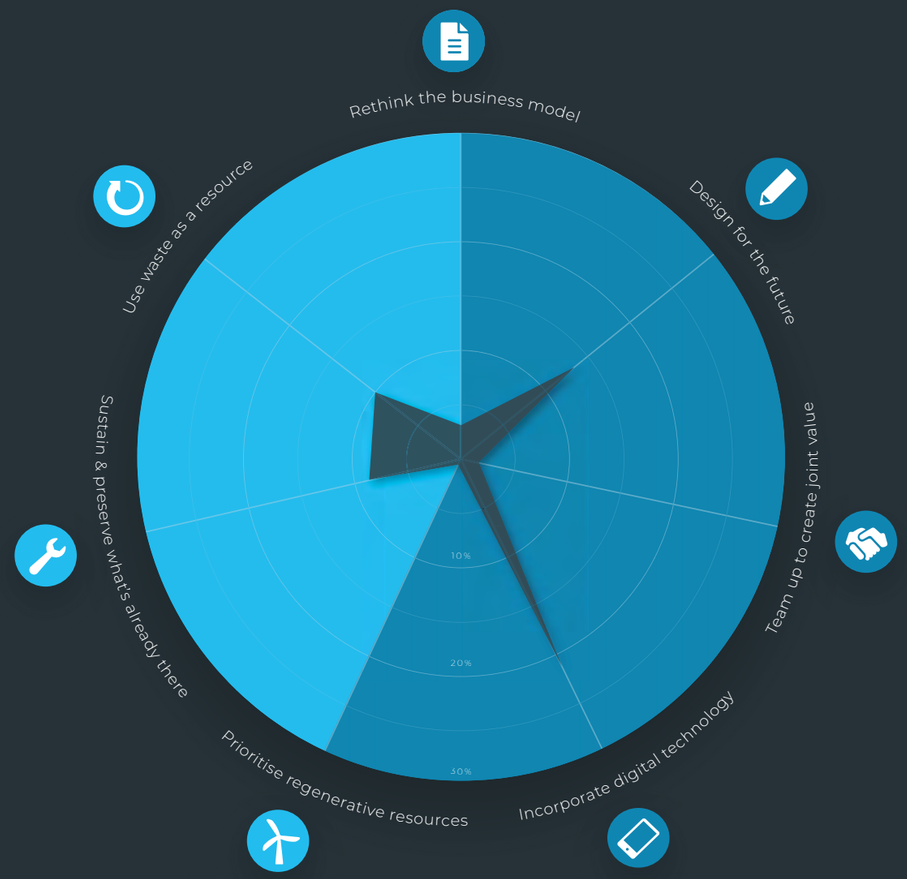
South Western Scotland

In total, 82,181 jobs in the region are related to the circular economy (7.7% of all jobs in the region).

South Western Scotland has more core circular jobs than any other region in Scotland (15,464 or 18.8% of all circular jobs in the region). The majority of these are in Glasgow City, which may be because many companies are headquartered in the city and register their data there, although operational activities may take place elsewhere.

Some 32,217 jobs are generated in enabling circular sectors (39.2% of all circular jobs). As in line with the rest of the country, a large proportion of the enabling jobs are generated in design and technology which together account for 34.5% of all circular jobs in the region.

In line with the rest of Scotland, most circular jobs in this region are generated by sectors indirectly supporting the circular economy (34,500 jobs or 42% of all circular jobs in the region). These jobs are mainly generated through demand for core circular products or services by the healthcare and social work, public administration, manufacturing, and wholesale and retail trade sectors.



Part 2: Roles and Skills to Power the Circular Economy

The employment analysis in the previous chapter paints a picture of the number and range of jobs already contributing to the circular economy in Scotland. This chapter looks in-depth into three value chains that will be key to Scotland's circular economy - construction, capital equipment and the bioeconomy - to get a better understanding of the roles and skills requirements of these value chains.

The transition to the circular economy implies a change in production, design and business models, which will transform existing jobs and create new roles [22]. These roles in turn require different and sometimes additional skill-sets. Getting clarity on what skills are needed is vital to reducing and avoiding skills gaps and shortages to forge a resilient and sustainable circular economy. A successful transition to a circular economy will depend on both the skills available and how the skills that are needed in the labour market are developed [23].

Jobs in the circular economy are likely to involve a combination of more traditional skills, such as the skills used for repair, sorting and spotting faults during production processes, and more novel skills such as those associated with modular design and material compositions. In many cases, working with circular business models will require more diverse and adaptive skills and mindsets [24]. Soft skills for collaborating across sectors and service-related skills will be just as important as hard skills for programming, operating and repairing equipment [25].

The circular economy provides vital opportunities across all areas of the Scottish economy, from agriculture to education. However, this report looks in-depth at three priority value chains which Zero Waste Scotland's business experts identified as key to meeting Scotland's landmark net-zero pledge [26] to end the waste and related emissions behind the climate crisis by 2045 and creating valuable sustainable jobs in the circular economy.

Workshops were held internally with Zero Waste Scotland's sector experts to map (a) the nature and extent to which circular strategies are currently being utilised within these value chains in Scotland and (b) the potential for these strategies to be increasingly applied in the sectors relevant to each value chain. The most prominent strategies were mapped during the workshops and informed a series of 19 interviews with additional external sector stakeholders to validate the selected strategies and gain further insight on:

- the key opportunities for promoting the circular economy in Scotland, including their feasibility and relevance to Scotland;
- the job roles and skills that are required to realise these opportunities;
- the education and training required to secure these skills in the labour market.

The three key value chains and related circular strategies which were identified and analysed to assess potential new roles and the skills those jobs would require were:

- **Construction:** Offsite construction; digital technologies in building and materials management; closed-loop cycling[9] of building materials.
- **Capital equipment:** Repurposing and reuse; remanufacturing and refurbishment including decommissioning oil rigs and wind turbines; products-as-a-service (to lease rather than to own).
- **Bioeconomy:** Biorefining; anaerobic digestion.

Consultation with our experts and external stakeholders identified a range of different factors suggesting that increasing circular activities within these three value chains would yield significant gains for the Scottish economy and labour market.

These factors included the untapped potential for circular activity where success has been demonstrated abroad, such as using digital technologies in building and materials management - or in the bioeconomy through businesses such as insect farming, which Scotland is in a strong position to replicate given its existing food and drink sector.

A second significant factor was the potential for the redeployment of a key workforce, with growing opportunities in Scotland's energy sector through the decommissioning of oil and gas fields and wind farms.

The report presents a first assessment of circular strategies within the three key value chains which were identified to outline the real opportunities they each offer for Scotland now. It is a starting point to help develop the national circular economy Scotland needs.

The socio-economic landscape of the sectors and strategies involved in the three value chains in this report is set out in the next section. This is followed by an in-depth analysis and description of how roles, skills, tasks and activities will change and emerge to enable the achievement of the net-zero target to end the nation's contribution to the climate crisis by 2045.

The language used to refer to skills needs for each key role in this chapter draws on Skills Development Scotland's Skills 4.0, known as the Metaskills framework, and the European Commission's European Skills, Competences, Qualification and Occupations (ESCO) models [27,28].

[9] Closed-loop cycling of materials and products is focused on supply chain and whole-life sustainability. Closed-loop systems are designed so that materials can be recycled with little or no degradation, or can be captured higher up the waste hierarchy and be reused.

Construction

Current State of Play

The construction sector uses more natural resources than any other sector in Scotland, consuming about half of all resources used nationally annually. This is mainly due to its demand for aggregates, which totals 29 million tonnes each year [29].

Construction and demolition work is also responsible for nearly half of all Scotland's waste annually [30].

The type of materials used in construction has a significant impact on the emissions from those resources. Some 95 per cent of construction demolition waste is recycled in Scotland but it is predominantly downcycled.

Switching to more responsible consumption through adopting more circular ways of building can significantly reduce Scotland's emissions from the use of resources and the waste of those materials.

In addition, 60% of all building materials used in the UK are imported from the EU. Approximately £315m of the total £520m building materials imported for Scottish housebuilding is estimated to have come from the EU in 2017 [31].

With exports of building materials to the EU significantly lower, this results in a UK trade deficit of just over £5.9 billion [31]. The construction sector is also a large employer, providing over 230,000 jobs. It generates £11.1 billion GVA [32].

Circular Jobs in Construction Now

The national baseline analysis found that the construction sector generates almost 3,752 indirectly circular jobs in Scotland (1.8% of all circular jobs). This corresponds to 2.7% of all jobs in the construction of buildings, civil engineering and specialised construction activities (SIC 2007 Section F). A range of circular activities within the sector may be underrepresented in this analysis as it only considers jobs in the construction sector that are indirectly created by the circular economy and due to the way activities are classified across sectors. Please refer to the Annex for information on how employment in the three activities discussed below are, or are not, represented in the baseline analysis.

Future Circular Jobs, Roles and Skills in Construction

Zero Waste Scotland and Circle Economy identified three circular economy strategies within the construction value chain as being increasingly used in Scotland, or as having significant growth potential for a national circular economy. These are offsite construction, closed-loop cycling of building materials and components and digitisation of buildings and material management.

These strategies, the potential jobs they generate and the skills required to fill these roles are outlined here.

Offsite Construction

Offsite construction (OSC), also known as prefab construction, refers to the manufacture and assembly of building components and modules in a factory, which are then transported and installed onsite [33]. The modular approach to designing and constructing buildings used in offsite construction supports several principles of circular construction, including resource efficiency, lean construction, life-time extension, and preparation for reuse, retrofit and deconstruction.

OSC makes use of modular construction techniques, which can reduce 70% of onsite waste, increase the speed of construction on site by 50% and therefore reduce capital costs by 10% [34]. OSC can also improve health and safety for employees due to fewer onsite workers and physically demanding roles. It is being positioned as the solution to a number of other issues traditionally faced by the construction sector, including affordable housing, improving energy efficiency and reducing cost, waste and lifecycle carbon emissions [35].

Previous research has found that 1,800 jobs are directly provided by the OSC sector in Scotland [35]. There are 33 OSC companies active nationwide, most of which use wood as the main material, while a minority use steel and concrete. While 80% of new homes are already being built using OSC techniques [35], the majority involve simple two-dimensional open panel timber frames as opposed to full volumetric modular construction. In early 2020, the sector predicted a growth of 18% between 2020 and 2025, with employment expected to increase by 2% over this time, a slower growth mainly due to efficiency gains in the sector [35].

Roles and Skills for Offsite Construction

Key Takeaways:

- Transformation of onsite specialised operatives into multi-skilled operatives, requiring an adaptive set of manual and technical skills.
- Increased employment in offsite, factory-based roles, requiring similar profiles to current construction workers and roles on manufacturing production lines.
- Emergence of specialist OSC quality assurance roles on site, requiring building surveying certification and strong information skills.

Growth of the OSC sector in Scotland will result in a gradual transition away from onsite roles to offsite factory-based roles. As structures and components are largely built offsite, fewer specialised onsite tradespeople are needed. Instead, **multi-skilled operatives** with a wider skill-set than traditional tradespeople are needed to carry out finishing work onsite.

Quantity surveyors and **inspection advisors** will become increasingly important for maintaining high quality standards and confidence in the industry as it grows. Offsite, more specialised roles will become the norm, with an increase in demand for workers with a higher and narrower skill-set. Skilled **production assemblers, joiners** and **finishers** will work alongside **factory-based operatives** in lean production environments, with roles becoming more similar to those seen on the shop floor within manufacturing. **Designers'** and **architects'** roles will be redefined to embrace modularity, layering and adaptability of the built environment, with a focus on designing energy efficient buildings with standardised components.

Given that OSC calls for a greater number of stationary factory-based roles, growth of the industry could encourage a demographic shift in the workforce. This could include opening up job opportunities for different groups, such as women, people from Black, Asian and Minority Ethnic (BAME) groups and those living close to the factories who may have otherwise struggled to work onsite due to working conditions, such as health and safety; weather; seasonality; or travel [36].

OSC could thereby help to increase diversity of the workforce, not least due to the access to and use of lifting devices and robotic arms which reduce the need for high physical strength. It could also help to meet the challenge of skills gaps and attract more young people into career pathways in what will be a safer and healthier working environment [37].

Multi-skilled onsite operatives

Tasks

- Installing prefabricated units and components from the factory on site.
- Finishing spaces for use, including plastering, painting, tiling, and flooring.
- Proactively identifying bottlenecks and solutions to problematic joints and assembly.

Skills needs

- Adaptive skill-set, with the ability to easily switch between tasks and disciplines.
- Manual and technical skills to operate basic construction equipment.
- Ability to work under minimal supervision, high degree of self-management, initiative and independent thinking.

Relevant qualifications

- Vocational, cross-training in mechanical, electrical, plumbing (MEP) trades. SCQF Level 5-7.

Quantity surveyors, inspection advisors

Tasks

- Promoting safety and quality in undertaking accurate surveys on and offsite.
- Inspecting and certifying factory-made and secondary components and volumetric systems.
- Providing advice to manufacturers on quality management and assurance.

Skills needs

- Experience of surveying buildings and quality assurance with specialist knowledge of current regulations and health and safety standards relevant to OSC.
- Strong information skills, communication skills and empathy.

Relevant qualifications

- First degree SCQF Level 7-9/10 or advanced training/ qualifications in Quantity Surveying or Engineering SCQF Level 10-12.

Closed-loop Cycling of Building Materials and Components

Closed-loop cycling of building materials means that they are no longer sent to landfill or downcycled for use in other sectors. Instead, materials and components are fed back into the construction of new buildings or renovations of existing structures which retains the highest value. Closed-loop recycling is made possible by small improvements across the value chain to divert materials from landfill, which would have a large impact on both material savings and skilled job opportunities [38].

The Scottish construction sector currently has a high recycling rate of 97.3% [39]. Yet, this is mainly due to large scale, low value downcycling of materials, which are used for base material in road construction, or as quarry fill or landfill top cover. Of the Scottish demand for construction aggregate, which is at 29 million tonnes, only 20% is met with recycled aggregates or secondary products, compared with a UK rate of 28% [29].

For the recycling of steel, Scotland is completely reliant on facilities abroad. Every year, over 500,000 tonnes of scrap steel is exported [40] with a commodity value of £180 million. This is likely to increase significantly over the coming decades due to the increasing decommissioning of oil and gas assets. The value of secondary steel made from scraps is three to four times higher than the price of scrap. Increasing steel recycling by locating an Electric Arc Furnace (EAF) plant in Scotland would increase Gross Value Added and has the potential to create 180 direct and 1,000 indirect jobs [41]. This is supported by the fact that Scotland has one of the least carbon intensive energy grids in the world, meaning that reshoring steel recycling would make environmental sense. A key barrier to reshoring steel recycling to Scotland are the high electricity prices, as energy consumption by EAFs, required to melt scrap steel, is substantial. As such, there is a significant opportunity for both material and cost savings in the higher quality recycling of building materials such as aggregates, plasterboard, steel and aluminium [42] as well as higher value capture and reuse of building components.

Roles and Skills for Closed-loop Cycling of Building Materials and Components

Key Takeaways:

- Transformation of roles in demolition, architecture and procurement to include digital and technical skills, respectively, for designing and selecting high-value deconstruction methods.
- Increased employment in the handling and sorting of secondary construction materials with manual skills for reducing contamination of construction materials.
- Increased employment in highly-skilled material and product innovation roles, requiring systems thinking and knowledge of the supply chain.

The use of secondary materials in construction presents opportunities for creating jobs across the value chain in the sourcing, sorting, testing and supply of high-quality secondary materials. Because the ability to capture, reuse and recycle building materials and components is strongly linked with the way buildings are deconstructed, **site analysts** and **deconstruction auditors** will need to use different approaches to locate and reduce damage to reusable components or recoverable materials from buildings.

They will ensure site harvest management plans are in place, replacing site waste management plans in order to reflect the value that can be harvested from buildings. **Demolition labourers, supervisors** and **technical managers** will also need to understand the value of secondary products, components and materials and the processes required to prevent material contamination, facilitate efficient recycling and minimise damage to recovered elements.

Roles such as **materials innovation specialists** and **product developers and manufacturers** will be needed to create a market for products made from secondary materials. There will also be opportunities for new roles such as **low carbon specialists** and **sustainability advisors** to work with companies developing these products to ensure factors like their weight or method of transportation do not outweigh the carbon savings of giving materials a second life. **Sales and marketing professionals** will also be vital in growing the market and encouraging procurement staff to switch from primary to secondary materials.

Architects will need to work in new ways to promote the reuse of materials and disassembly of buildings through their designs. **Material scouts** will be concerned with finding secondary materials and products in the region that could be used for new construction projects. They need to be highly familiar with the area, well connected with local stakeholders to locate the right materials, and work closely together with the architect to integrate them into the design.

Procurement specialists are required to not only ensure a steady pipeline of building materials within the market, but to also ensure contractors factor in sufficient lead-in time for the sourcing of secondary materials. This will be crucial to changing practice and preventing contractors, both public and private, from reverting to primary materials, particularly due to the time sensitive nature of the construction contracts which typically limit the level of collaboration and planning required in a circular economy. This work will need to be supported by the development and active dissemination of guidance for public and private clients on the utilisation of secondary materials, the associated benefits and how they can be sourced.

Urban planners and **planning authorities** will need to ensure all development plans take responsibility and support the infrastructure for the collection of secondary materials, including the required employment. Development plans will need to identify suitable sites for processing materials left over from construction or deconstruction processes, ensuring where possible materials are diverted from landfill.

Site analysts, deconstruction auditors, urban miners

Tasks
- Assessing and auditing buildings for deconstruction.
- Ensuring proper site harvest management plans are in place.
- Scouting and identifying materials and components to be recovered.
- Conducting thorough assessments of the reusability of materials and components, understanding health, safety and material constraints.
- Selecting appropriate deconstruction methods to maximise the quality of recovered materials.

Skills needs
- Strong technical focus and initiative for selecting safe options for deconstruction.
- Systems thinking, knowledge of urban metabolism and secondary material value.
- Digital skills, experience with BIM Level 2 and material passports.
- Experience of surveying buildings and quality assurance with specialist knowledge of current regulations, health and safety standards relevant to offsite construction.
- Strong information skills, communication skills and empathy.

Relevant qualifications
- Advanced training/ qualifications in Structural Engineering or Construction Management SCQF Level 10-12.

Material innovation specialists, product developers

Tasks
- Developing innovative products for construction using secondary materials.
- Analysing and evaluating secondary material flows to continuously scan the market for gaps and potential new solutions.
- Working with suppliers to build sustainable pipelines utilising secondary materials.
- Applying modern construction techniques to innovation process management.

Skills needs
- Systems thinking, understanding of reverse logistics and the supply chain.
- Executive management, business and data analysis skills.
- Innovation skills, including curiosity, creativity, sense-making and maker mentality.

Relevant qualifications
- Advanced qualifications in Civil Engineering, Industrial Design, Material Science or Earth & Environmental Science, SCQF Level 10-12.

CASE STUDY

KENOTEQ

Kenoteq

Kenoteq produces the K-Brick. Made of +90% recycled construction and demolition (C&D) waste from Scottish Environment Protection Agency (SEPA)-certified C&D recycling plants, it produces only one tenth of the carbon footprint of traditional fire-clay materials. The processes used are 100% zero-waste (compared to 10-20% waste in normal brick manufacturing) and help to close the construction material loop. The product is SEPA approved and in the final stages of receiving BBA certification. The product is a different concept to others on the market.

Kenoteq is a small company in the process of scaling up. It plans on expanding the number of staff on site and in the office and purchasing new machinery to reach a target of 3 million bricks per year. The team currently consists of:
- **Chief Executive Officer** has a background in building materials life-cycle assessment and runs the company.
- **Chief Technical Officer** has a civil engineering background and leads the technical development of the K-Brick.
- **Technical and Operations Engineer** has a background in structural engineering with architectural design and leads all testing and (ISO) certification of materials.
- **Operations team.** On site working on the manufacturing of the brick, skilled technicians with experience in construction and know how to handle valves, big quantities of materials, etc and are hands-on:
  - **Operations Manager** has a background in onsite operations, oversees the functioning of the manufacturing process.
  - **Two Operators** working under the Operations Manager's supervision.

It is hard to find people well-equipped with defined skills but Kenoteq is able to develop capabilities and potential in-house. Technical skills from the construction, demolition and manufacturing industries are very valuable in this business. Thanks to its innovative nature, Kenoteq is actively collaborating with Heriot-Watt University for research and development.

Whereas the innovative product is very attractive for many people to work with, Kenoteq acknowledges that not everyone has the appetite to work with a small start-up. New recruits need to firmly believe that the future of construction can be sustainable and want to contribute towards this. Working together towards a goal, to have a low environmental impact with everything we use (materials, processes etc), is key to Kenoteq. This mindset is not even comparable to more linear companies.

Digitisation of Buildings and Material Management

Digitisation of material management for new buildings in the construction sector is done through Building Information Modelling (BIM), a way for creating digital 'twins' or 3D virtual models of buildings, their properties and components. BIM is an invaluable tool for supporting the construction of buildings, which can also be used to drive material efficiency and reduce waste over a building's lifetime.

BIM-based material passports are designed to support end-of-life assessment of the reusability and recyclability of embedded building materials [43]. Artifical Intelligence and scanning software can be used to identify the materials in existing buildings.

Information tools like these can raise awareness of the harvesting value of secondary materials and the impact of decisions made by different workers across the lifespan of a building. In this way, it can be used as a tool for collaboration and communication on circular principles. This bridges some of the traditional challenges related to the limited responsibility held by workers at different points in the value chain past the point of delivery.

Digital technologies have created opportunities for increasing the transparency, efficiency and productivity of the construction sector. They can drive the uptake of whole-life approaches, support systems thinking and decision making of workers across the value chain, from design to deconstruction.

Although these practices are increasingly becoming the norm across Europe, BIM is not widely used in Scotland. However, since the publication of the **Construction Procurement Review** calling for all public sector projects across the country to adopt a BIM Level 2 approach by mid-2017, BIM is increasingly considered an integral part of the future of the Scottish construction sector [44].

Roles and Skills for the Digitisation of Buildings and Material Management

Key Takeaways:

- Transformation of roles in facilities and asset management requiring strong communication skills as well as BIM Level 2 proficiency.
- Transformation of roles across the value chain to include digital skills that make use of BIM and embrace collaboration.
- Increased employment in data, software development and tool development, requiring technical, innovation, creativity and sense-making skills.

If utilised to its full potential, BIM can hold information on the type, length, lifespan, height and circularity of materials. This can support **investors, designers, urban planners, developers, asset managers, facility managers** and **project coordinators** to better collaborate and to set realistic lifespans for buildings, moving beyond the arbitrary 60 year life for which many buildings are currently designed [45].

Knowledge and understanding of BIM amongst these existing professionals will facilitate better collaboration and more informed decisions about the design, maintenance or deconstruction of buildings by facilitating systemic thinking and communication about the value of materials and components embedded in the built environment. **Repair operatives** and **technicians** will also be able to utilise BIM in repair and predictive maintenance schedules.

Within larger construction companies, **data analysts, BIM programmers** and **software engineers** will be needed to maximise the value of data and bring it together in an accessible format that can be used by professionals across design, maintenance and deconstruction of buildings.

These same teams are likely to be involved in the development of new BIM-based products and solutions which can be sold or provided as a service to businesses who want to capitalise on the lifespan and harvesting value of building materials. This can help them to, for example, more robustly estimate the volume of material and storage processes required for a project.

Facility managers, asset managers, project coordinators

Tasks

- Managing the pre-planning, production and construction of new developments.
- Analysing newly procured buildings for renovation or reuse using BIM.
- Ensuring site harvest management plans are in place prior to works.
- Managing third party contractors for repair, maintenance or deconstruction.
- Updating BIM platforms and material passports following renovations, or the introduction of materials innovations and new construction techniques.

Skills needs

- Management and leadership skills, communication for leading collaborative processes.
- Digital skills, confidence with BIM Level 2, knowledge of construction techniques and building specifications.

Relevant qualifications

- First degree SCQF Level 7-9/10 or advanced training/qualifications in Urban Planning, Construction Engineering, Civil Engineering or Construction Management SCQF Level 10-12.

Data analysts, BIM programmers and software engineers

Tasks

- Integrating, interpreting and maintaining BIM systems.
- Working with others to translate complex materials and components into the digital environment.
- Updating information on the lifespan and circularity of materials in line with emerging materials innovations and new construction techniques.
- Developing tools and interfaces to constantly improve access to and usability of BIM.

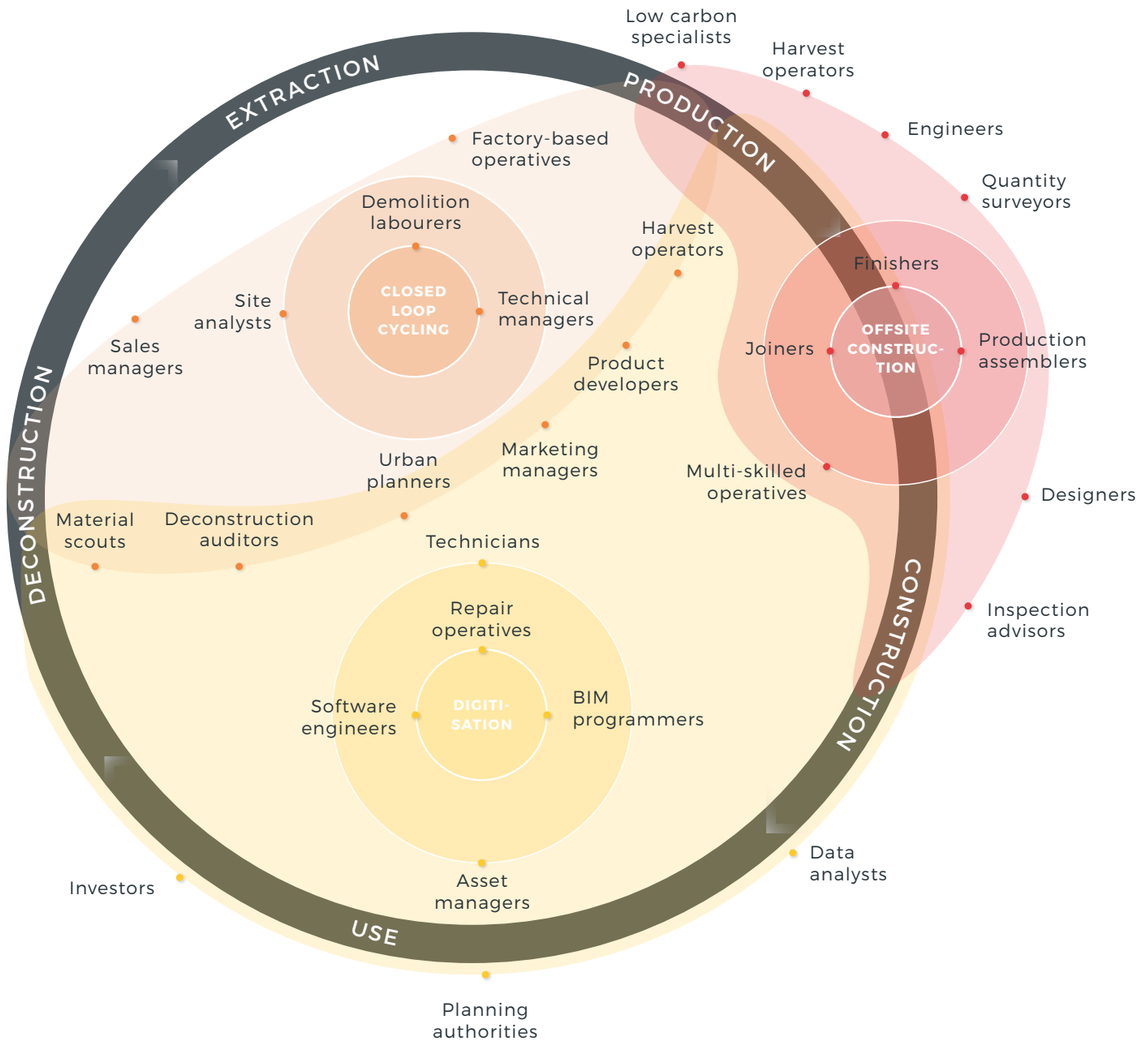
Skills needs

- Programming and coding skills, confidence with BIM Level 2.
- Innovation skills, including curiosity, creativity and sense-making.
- Agile and lean working style, with ability to adapt and self-educate.

Relevant qualifications

- First Degree SCQF Level 7-9/10 or advanced training/qualifications in IT or Software Development (preferred) SCQF Level 10-12.

Construction



Skills Pathways for the Construction Value Chain

There is a cyclical shortage of skilled labour in the construction industry. Attracting the right talent should be addressed alongside the needs below. High initial costs are specifically predicted for both capacity building and training in the area of offsite construction, which needs to be taken into account alongside the shortage of skilled labour across the industry.

1 From specialised to multidisciplinary operatives and graduates

- Education and training for the construction sector is currently structured around traditional onsite roles. There are challenges around training and upskilling workers for multi-skilled roles relevant to OSC, given that professionals working in mechanical, electrical and plumbing roles are generally skilled via targeted traineeships and apprenticeships.
- Interdisciplinary cross-traineeships and apprenticeships should be developed, with the inclusion of systems thinking and supply chain awareness embedded across all vocational and higher education training for the construction industry.

2 Innovative forms of learning and knowledge exchange

- Specialised skills required for circular strategies could be supported through certified bespoke training packages delivered in-house or to workers moving roles with existing experience of the industry. The Construction Scotland Innovation Centre (CSIC) has already developed Offsite Ready, a series of training resources that will improve the quality and consistency of training in offsite construction that could be built upon [46]. As many of the skills and mindsets required across the circular construction value chain will be transferable, there is a role for the Engineering Construction Industry Training Board (ECITB) Connected Competence programme to play [47].
- Educator upskilling is a major requirement across the sector as many educators may not be familiar with all modern construction techniques. This could include OSC factories being open to educators to visit or industry practitioners taking up teaching assignments by providing workshops, training, challenges, advice to students and internship opportunities.

3 Upskill on digital and increase digital literacy

- Many principles of circular construction require a digitally-enabled workforce. Government support in the form of training grants could support the roll out of the required digital skills through short-term training programmes. Agencies like Skills Development Scotland,the Scottish Funding Council, CSIC, Construction Skills, as part of the Construction Industry Training Board (CITB) and ECITB can all play a role here.
- However, the existing level of digital literacy in the sector must be taken into account. Basic digital skills and digital communication skills are required and therefore should be prioritised before training is rolled out on more advanced solutions.

4 Drive demand for circular construction skills using public procurement

- Whereas Scotland's zero-waste and circular economy ambitions have been formulated, market uptake of these ambitions may take longer. There is a significant opportunity to drive uptake of circular strategies by driving the development of circular skills. Upskilling and reskilling private sector workers for circular construction needs to go hand in hand with the upskilling of public bodies. This is vital for the public sector to help influence the market through public procurement, including through affordable housing and the repair and retrofit of these buildings [42].

Capital Equipment

Current State of Play

The manufacturing sector employs 179,000 people across Scotland [19]. It is an important employer, which produces half of Scottish exports and is the largest investor in business research and development. However, the sector has undergone significant changes, moving away from traditional manufacturing to a more service-oriented economy. It is also at highest risk of being negatively impacted by Brexit [48,49].

The priority, therefore, now lies with high-value manufacturing, and investment in the development of science, technology, engineering and mathematics (STEM) skills at all levels of education in line with Scotland's national STEM strategy [50].

Opportunities for the manufacturing sector in relation to the circular economy have been identified as increased productivity and more efficient production, product and supply chain innovation, strong customer relationships, greater resilience and job creation [48].

Circular Jobs in Capital Equipment Now

Our analysis finds that the **manufacturing sector generates almost 19,451 circular jobs** (9.4% of all circular jobs). This includes over 9,056 indirectly circular jobs in the manufacturing of products (SIC 2007 10-32) and 10,395 jobs in repair (SIC 2007 33.1). This initial employment analysis considers all jobs in the repair sector. Yet, in the manufacturing of goods sector, as in construction, a range of circular activities are currently happening which may be underrepresented in this analysis. Please refer to the Annex for information on how employment in the three activities discussed below are, or are not, represented in the baseline analysis.

Future Circular Jobs and Skills in Capital Goods

Zero Waste Scotland and Circle Economy identified three circular economy strategies within the capital equipment value chain as being increasingly used in Scotland, or as having significant growth potential for a national circular economy. These are reuse and repurposing; remanufacturing and refurbishment; and product-as-a-service models (such as leasing instead of selling goods).

These approaches, the potential roles they generate and the skills required to fill them are outlined here.

Reuse and Repurposing

Reuse and repurposing consists of recovering components rather than recycling materials, and so aims to preserve more value after use of resources. Within Scotland, the decommissioning of legacy energy infrastructure such as pipelines and offshore drilling platforms, and in the near future a first generation of wind turbines, will go hand in hand with the energy transition. Decommissioning this infrastructure can happen in very different ways, from leaving the structure intact, to relocation to reuse and repurposing.

At least 60% of oil and gas platforms in the North Sea will be decommissioned by 2030, representing close to a million tonnes of materials[10] [51]. Additionally, more than 1,500 onshore wind turbines will also reach their end of life by 2030[11], having been operational for over 20 years by this time [52].

While a complete set of environmental, financial and socio-economic factors need to be taken into account when decommissioning old infrastructure - sometimes the most desirable option can be to leave the structure intact and in place [53] - reusing and repurposing can yield multiple benefits. Although the right regulations need to be in place to enable reuse and repurposing of these assets, benefits can include [54]:

- reducing the environmental impacts associated with the recycling or disposal of materials
- reducing the net cost of decommissioning
- developing new markets in the face of a lower oil price economy
- retaining employment and skills in the national economy.

As the majority of materials and equipment from old energy infrastructure are currently downcycled, which is low value, there is a significant opportunity in pursuing high-value reuse and repurposing. Considering the potential scale, complexity and market in Scotland, the main opportunities are in component reuse and equipment reconditioning [54].

Roles and Skills for Reuse and Repurposing

Key Takeaways:

- Shift in employment and transference of skills from the production to the repurposing of capital equipment.
- Increase in employment of highly-skilled industrial designers, material specialists and product developers, requiring knowledge of material applications in sectors.
- Emergence of specialist reuse roles with skills for data and market analysis.

There are significant and largely untapped supply chain and employment opportunities associated with the reuse and repurposing of assets, particularly from the energy sector in Scotland, from the removal of assets to finding markets for systems and components currently held within industries [54]. These job opportunities will increase as the decommissioning process in the North Sea advances and the first wind turbines reach their current end of life.

It is estimated that the economic value of oil and gas decommissioning activity to Scotland over the next decade could be between £5.7 billion and £7.7 billion (2017 prices; GVA); supporting peak employment of 13,500 – 18,150 [55]. Further economic value is expected from wind turbine decommissioning.

Establishing high-value industries around the reuse of energy assets will require highly-**skilled industrial designers, material innovation specialists** and **product developers** to experiment and innovate around the reapplication of assets in other industries. Alongside designing new products, **reuse specialists** will be needed to test markets and conduct feasibility studies to ensure a route to market for new products, be that in renewable energy, agriculture, construction or other industries. For example, the innovation opportunities associated with repurposing wind turbine assets, such as the fibreglass blades which currently are not easily recycled, are largely underexplored as only a few wind turbines have been taken out of service to date.

Brokers and **data analysts** will be required to develop and populate a national database of assets. Here assets coming out of service or unused components in storage can be logged according to their properties and matched to opportunities for reuse or repurposing.

The oil and gas industry holds a wealth of expertise in skilled processes, such as fabrication. Workers in roles like **fabrication engineering** will be well suited to applying their skills in the wind industry or the repurposing of capital equipment from the oil and gas industry for use in other industries. Similarly, the safe dismantling, transportation and handling of large components required to bring these assets onshore, will require skilled labour largely already present in the industry in roles like **heavy lifting engineers**. In other cases, more extensive upskilling will be required to deploy skills from the automotive and oil and gas sectors to this growing industry.

[10] This estimate is for the tonnes of topsides slated for removal across the North Sea.
[11] Includes only onshore wind turbines that have started to be operational before 2010. The useful life of a wind farm is 20 years.

Industrial designers, material innovation specialists, product developers

Tasks
- Identifying practical applications and material solutions for entire decommissioned assets and components.
- Working with stakeholders from different industries to identify opportunities for the application of decommissioned assets and components.
- Analysing and evaluating data on pipelines of assets to identify opportunities.

Skills needs
- Digital skills, experience of digital manufacturing systems and processes.
- Innovation skills, including curiosity, creativity, sense-making and maker mentality.
- Executive management, business and data analysis skills.
- Strong information skills, communication skills and empathy.

Relevant qualifications
- First degree SCQF Level 7-9/10 or advanced qualification in Product Engineering, Material Science or Industrial Design SCQF Level 10-12.

CASE STUDY

Cesscon Decom

CessCon Decom provides decommissioning services across the whole decommissioning lifecycle from initial services offshore to end-of-life onshore dismantlement, decontamination and recycling. The company's target is to reach a minimum of 98% reuse and recycling rate in each project. It has its own welding, fabrication and construction company, as well as a Computer Numerical Control (CNC) milling, machining and engineering company, so valves and pumps can be refurbished before being sold.

Determining the potential for reuse of components within the oil and gas industry and other industries for projects is a team effort, requiring input from the Project and Operations Director (identifying the potential reuses for each technical part), the Health, Safety and Environmental Manager (assessing the contamination and requirements for reuse in different fields), the Regulatory Compliance Manager (interested in circular economy), and the engineering team.

A decommissioning project team typically consists of 30-50 people from across the organisation and includes:
- **Management team** [5-10 people]: Oversight and planning.
- **Tendering team** [8-10 people depending on complexity]: Tendering for all the projects; includes a tender manager, a project manager, engineering staff, logistics, planning, operations and execution teams are consulted.
- **Contract team:** Negotiating contract terms and conditions.
- **Project team:** Led by a project manager with support from the engineering and operations team to engineer the full project from start to finish before the platform arrives at the yard.
- **Operations team:** Led by the site manager, the project director and the engineering manager, handle the assets when they arrive at the yard for the physical execution of the work.

CessCon Decom builds on the continuity of knowledge and experience, meaning that both engineering and operations execution of each given project is performed by the same team. Employees are routinely recruited from the oil and gas sector (95%) with experience in decommissioning, offshore operations, and onshore construction. **"If they know how to build it, it's easier to dismantle it."**

Whereas dismantling fundamentally requires the same skill-set, people and knowledge as demolition, the oil and gas decommissioning mindset needs to be shaped. Fresh and creative ideas for reuse are required.

CessCon Decom experiences significant interest in jobs within the decommissioning sector, evidenced by 28 applications received for a decommissioning project manager vacancy within one day.

Remanufacturing and Refurbishment

Remanufacturing has the potential to create environmental, social and economic value [57]. It aims to restore a used product to a state that it can be returned into the market and used to at least its original performance level, or to be better than a newly manufactured product. Refurbished products by comparison are generally not returned to an 'as new' state. Instead, underused or returned products are repaired to ensure their proper functioning and returned to the market with an adjusted warranty or reduced price [58].

Previous research has found that the **remanufacturing industry employs an estimated 19,000 people** in Scotland [59]. As remanufacturing activities gain in importance, additional jobs could be created as remanufacturing is, in general, more labour intensive than traditional manufacturing [59]. The Circular Economy Strategy for Scotland indicates the potential for remanufacturing to create an additional 5,700 jobs [7]. Potential employment gains in remanufacturing and refurbishment are highly contingent on productivity gains and technological advancement [60]. Remanufacturing of products could also reduce production costs by between 34% and 60% [59].

The Scottish remanufacturing industry currently revolves around four main industries: aerospace (3,400 jobs in remanufacturing, 66% of the sector), automotive (650-900 jobs, less than 1% of the sector), energy (10,000 jobs, less than 1% of the sector) and rail (160 jobs, 3.5% of the sector) [59]. Growth of the sector will expand the range of products it remanufactures, for example, to include medical equipment and ICT electronics, and the range of composite materials, secondary materials and digital technologies it uses [59].

Roles and Skills for Remanufacturing and Refurbishment

Key Takeaways:

- Increased employment in maintenance, repair and refurbishment of capital equipment, requiring similar skills to current manufacturing workers with some product and process specific skills.
- Increased employment in procurement and logistics, requiring more advanced skills in navigating complex, reverse logistics systems.
- Incremental increase in the skills of production workers and operatives as a result of vertical diversification.

Growth of the remanufacturing industry in Scotland presents opportunities for creating additional jobs for workers moving away from more traditional manufacturing companies. Given the strong foundation of manufacturing skills already present in Scotland, the transition towards more widespread remanufacturing is likely to require the incremental development of different skills rather than a significantly more highly-skilled workforce.

Aerospace, automotive, energy and rail are key high-value sectors in Scotland in which there is already significant remanufacture, repair and refurbishment. These skills will become more relevant if there is a trend towards reducing primary production and, for example, keeping existing aircraft in service rather than producing new aircraft. There are also particular employment opportunities associated with the refurbishment of wind turbines. To date, these have largely not been refurbished when faulty and instead disassembled and converted into scrap materials. Continually developing the skills and technologies used in the industry will help to open up different markets and job opportunities within Scotland.

Compared to linear production, remanufacturing involves more and complex steps to return a product to the market. Returning products or parts into the value chain via original equipment manufacturers, contracted or independent remanufacturers, will require them to be dismantled by **disassembly operatives** and tested by **test engineers** to determine whether they meet original specifications.

Once evaluated, worn-out parts will be sent for recycling and reuse in other sectors, and parts that meet specifications sent to be cleaned before **remanufacture engineers, fabrication specialists** and **technicians** then restore, replace or fabricate new parts or layers.

Lastly, the product is reassembled by **assemblers** and **operatives**. This process shows how the different steps in the production line are more closely interlinked and mutually dependent. This calls for an increased understanding amongst factory workers of the steps preceding and following them; a general upskilling as a result of vertical diversification of tasks. Workers may also require specific skills depending on the product and processes in use, including digital manufacturing techniques, additive manufacturing, composite materials or complex chemical components to achieve an as new product. All workers will require on the job training on product specifications to ensure the right tensions are built back into reassembled products. This training can be organised as required, as the production line changes between products. Much of the expertise and skills necessary for remanufacturing and refurbishment are held by those who have been working in the sector for many years and know the products they work with best. To ensure the legacy of these skills, efforts should be made to involve older workers in the training of new recruits on the job, through formal training, mentoring and coaching programmes.

In order to develop efficient services around the repair and refurbishment of offshore wind assets, **drone operators** and **remote high-precision service engineers** will be needed, facilitated by a data infrastructure for predicting failure rate.

It is critical that Scotland is at the forefront of the global digital economy. The Scottish Government's Digital Strategy [61] is aimed at driving greater use of system-wide data, predictive analytics and data-led approaches to identify and support sectors and firms which can exploit opportunities for growth and shape wider recommendations for economic priorities [62].

Growth of the remanufacturing industry relies on a sustainable pipeline of used products and parts. **Procurement officers** will therefore be needed to keep an overview of products and materials in the value chain and build relationships with suppliers to ensure a steady flow of high-quality input.

Logistics managers will be needed to manage the more complex logistical systems to transport products and materials to and from remanufacturers. **Sorters, recycling operatives** and **cleaners** will require upskilling to increase the range of materials that they can process and can therefore be used in the remanufacturing process.

Product designers will need to embrace designing for disassembly and make remanufacture a primary consideration in the design of new products and therefore a stronger understanding of manufacturing processes is needed amongst designers.

CASE STUDY

Renewable Parts Ltd

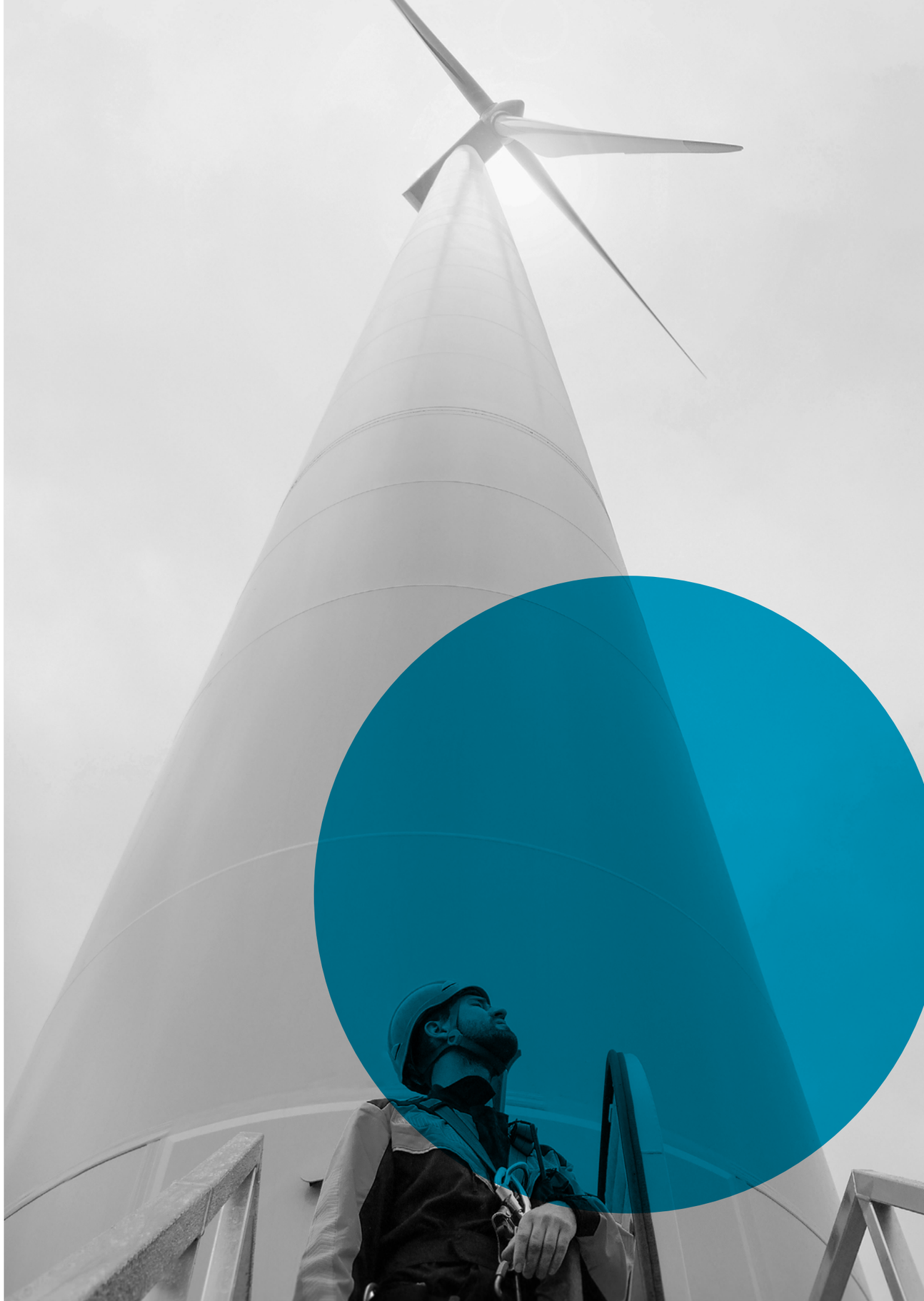
Renewable Parts (RPL) was founded in 2011 and primarily focuses on the refurbishment and remanufacture of wind turbine components, alongside this it delivers consumables and supply chain expertise to its customers worldwide.

The company currently employs over 20 people with over half directly involved in the refurbishment of wind turbines. As the interest in sustainability and the circular economy increases the company is planning its continued growth. Over the next 2 to 3 years it will employ another 10 to 15 people into its refurbishment arm and increase its workspace with a new, much larger, facility due to be completed in 2020.

RPL has three teams directly involved in its sustainability focused activities. These are:

- **Sales & Marketing** [4 people]: responsible for the external image of the business and the highlighting of company activities in sustainability
- **Procurement** [2 people]: responsible for identifying industry partners to create or improve sustainability in the supply chain
- **Operations** [6 people]: working alongside its customers in the refurbishment of wind turbines and innovation within its sector

Employees are recruited from a variety of sectors including more mature industries like automotive, aerospace, marine as well as newer industries like software. Technical apprenticeships are available for young people which enables them to become time-served technicians within the renewable industry.



Product-as-a-Service Models

Within product-as-a-service business models consumers do not buy a product to own it, but rather use and pay for the performance of a product. The so-called service economy manifests itself in many different ways, from leasing and pay-per-use to performance agreements [63]. Producers maintain ownership over products and resources, and are therefore incentivised to make products that last longer, are easier to repair, and easier to disassemble to capture harvesting value.

Service models on average yield marginal environmental gains, mainly due to efficiency gains in improved maintenance and lifetime extension of products alongside the extent to which products have to be transported from and to users [64]. For capital equipment, however, rental, sharing and pooling models can lead to high environmental gains as a consequence of intensive use [65].

The rental and leasing sector currently employs 20,000 people in Scotland [19]. The future macro impacts of these new business models remain under explored as little is known about the employment and economic potential of circular business models. On the micro level, circular business models entail higher transaction costs, but at the same time open up new markets and related business opportunities [66]. The promotion of product-as-a-service business models is included in the Scottish Government's circular economy strategy [7], as a way for operationalising circular design strategies for products by Scotland's enterprise agencies as part of innovation support for Scottish businesses.

Roles and Skills for Product-as-a-Service Models

Key Takeaways:

- Increased employment in the planning and management of resource flows, requiring a combination of skills for communication and logical reasoning and knowledge of material properties.
- Transformation of sales and marketing roles to encompass a combination of strong communication skills and different levels of technical product knowledge.
- Transformation of mindsets and management philosophy towards a service mentality and customer focused approach.

As the infrastructure and skills for remanufacture and refurbishment grows in Scotland, this will open up opportunities for transitioning towards product-as-a-service models. Providing products as a service would increase demand for desk-based roles focused on service planning for through-life, such as demand planners, asset managers and sales and marketing managers. It will also bring significant change in management philosophy and approaches to planning, including at chief executive and board level.

Product-as-a-service models would transform the roles in retail from sales to service providers. Shop assistants would become account managers and logistics managers. These roles would require strong communication and relationship building skills, as well as a servicing mindset and different levels of technical product knowledge.

Demand planners, asset managers, core brokers

Tasks

- Building relationships with suppliers to ensure a steady flow of high-quality materials.
- Analysing and evaluating supply chain data to identify correct components.
- Working with the sales team to forecast customer demand and available stock.

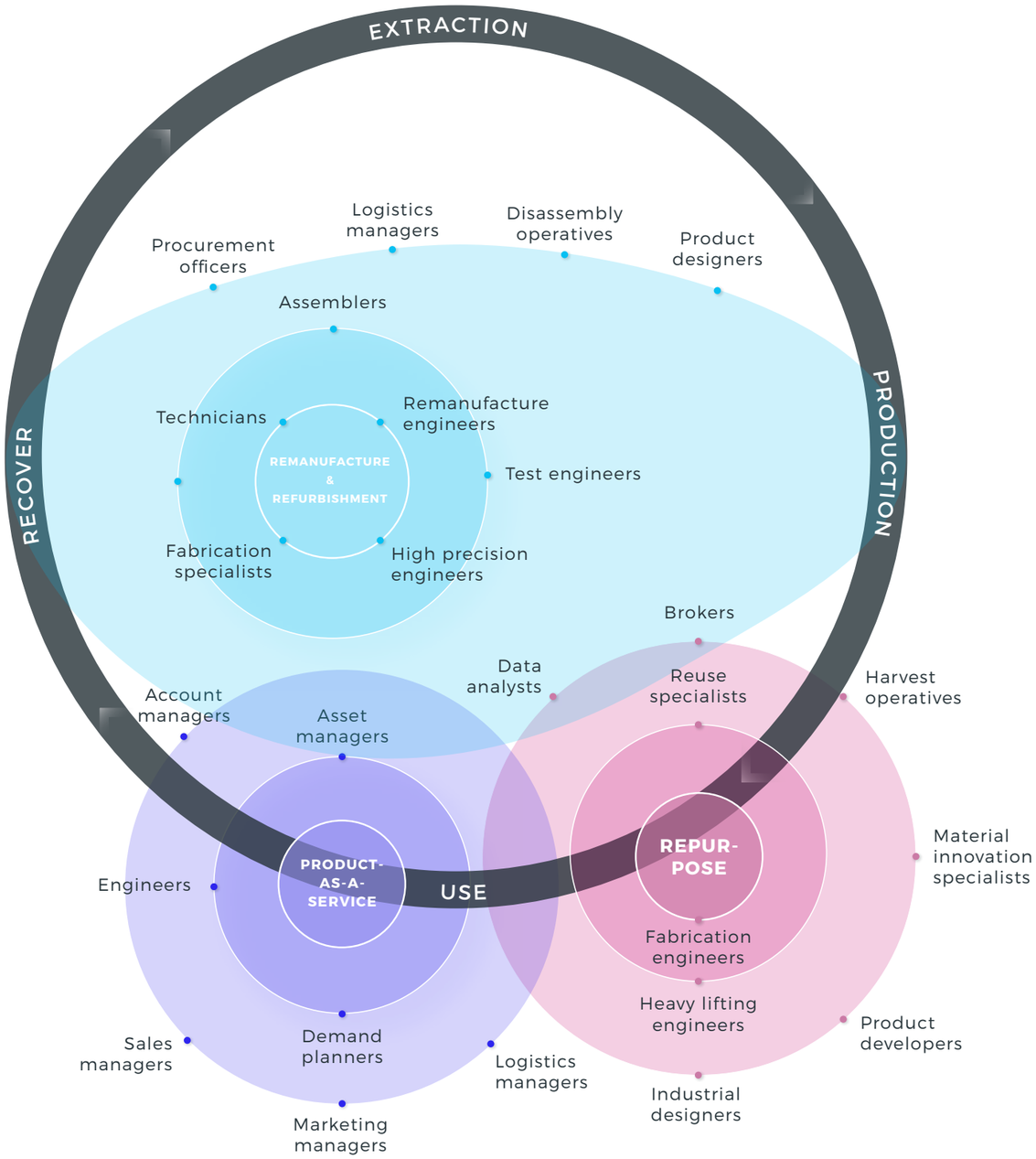
Skills needs

- Communication skills and experience in service delivery.
- Complex problem solving, logical and computational thinking.
- Executive management, business and data analysis skills.
- Knowledge of material properties and applications.

Relevant qualifications

- First degree SCQF Level 7-9/10 or Advanced training in Engineering or Business SCQF Level 10-12.

Capital Goods



Skills Pathways for Capital Goods

1. Integrate life-cycle thinking and digital literacy across product design, engineering and vocational education and training

- Current education and training pathways do not adequately prepare students for work in remanufacturing industries. The elimination of waste from production processes, complex problem-solving and life-cycle engineering should be integrated into vocational and higher education courses.
- Digital skills will be increasingly important as the sector increases its operational efficiency to meet its growth trajectory. Digital remanufacturing skills should be integrated into training for a range of occupational levels, including graduate and modern apprenticeships and Continuing Professional Development (CPD) programmes. These courses can take inspiration from recent courses developed by the University of Strathclyde on Digital Transformation [67].

2. Harnessing the legacy skills of older workers

- It is vital that older workers are afforded the same training opportunities so that they can remain competitive as sectors shift. At the same time, younger workers are most likely to be adversely impacted by recessions. In the context of the Just Transition, COVID-19 and the importance of building on the strong foundation of skills already present to grow the remanufacturing sector, intergenerational fairness will be an area for consideration in the design of new training pathways. One approach could be to engage workers approaching or recently in retirement in training programmes in order to share their expertise with new entrants and workers in need of upskilling. This would ensure important skills related to specific products and processes are not lost when those workers eventually leave the workforce. This could be delivered through modern apprenticeships, open learning platforms and other skills development courses in partnership with trade associations and relevant sector skills councils.

3. Develop hubs for skills development

- Skills hubs should be developed in collaboration with local colleges, universities and businesses for remanufacturing. These can provide an infrastructure for local skills development and accredited training, in line with the needs of emerging remanufacturing industries. The Scottish Funding Council, Skills Development Scotland, and sector skills councils could play a key role here.
- Innovation support and technology demonstrators, such as the Levenmouth Demonstration Turbine off the coast of Fife [68], will be crucial for developing the right skills in line with emerging practices. Organisations like the Scottish Institute for Remanufacture and National Manufacturing Institute Scotland could play a key role here.

4. Harness the redeployment opportunities decommissioning presents

- Decommissioning of North Sea oil platforms has already begun and large-scale decommissioning of wind turbines in Scotland is expected to begin in the next 10 to 15 years. Workers currently employed in the oil and gas industry could be deployed to work in the decommissioning of this infrastructure with little upskilling. Likewise, there will also be opportunities for these workers in the decommissioning of wind turbines and other industries in the future. If action is taken now to strategically upskill the workforce and match workers to new opportunities in the remanufacturing sector there could be enormous social, environmental and financial benefits for Scotland. Joint industry partnerships, catapult centres, which help businesses to transform ideas into products and services through their research and development infrastructure and the Scottish Offshore Wind Energy Council, can support this process.

Bioeconomy

Current State of Play

In 2018 alone, almost 1.8 million tonnes of organic waste material were collected nationwide, including over 400,000 tonnes of animal and food related waste generated by households and industry across Scotland [69]. The bioeconomy comprises those parts of the economy that use renewable biological resources from land, water and air such as crops, forests, fish, animals and micro-organisms and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy.

The bioeconomy is expanding and has the potential to produce value from by-products from agriculture, forestry, fishing, and the wider food and drink sector.

Zero Waste Scotland has estimated that harnessing value from by-products from the nation's beer, whisky and fisheries industries alone could be worth up to £800 million per year to the Scottish economy [70]. Some Scottish farmers and other biobased industries have always been good at diversifying business models to improve environmental performance and boost their income by finding innovative ways to design out or reuse wastes and by-product material streams on a small scale, but there is a clear and growing opportunity for larger scale and higher value reprocessing of bio-based materials.

As a reflection of the evolving bioeconomy and increasing integration of different sectors and industries, this would bring a demand for higher skills, reflecting the ongoing structural change of the sector, as manufacturing technology is increasingly introduced [71]. Scotland's Biorefinery Roadmap and the National Plan for Industrial Biotechnology provide frameworks for developing a more high-value bioeconomy, moving towards development of bio-based food, feed, fuel and materials [72,73].

The Scottish agriculture, forestry and fisheries sector employs 41,000 people, predominantly on the East coast and in the Central Belt. The fish industry employs just under 10,000 people, over half of which are employed in Aberdeenshire, the Western Isles, Orkney and Shetland and the Highlands [70]. Approximately 10,600 people are employed in whisky production, mostly in the Strathclyde, Central and Fife and Grampian regions [74]. Another 71,000 people are employed in the beer and pub sectors, dominated by two large producers and many independent brewers [70].

Expanding the bioeconomy to maximise the environmental, financial and employment opportunities associated with bioresource in Scotland will require roles and competences to be developed across agri-food sectors, as well as in industrial biotechnology. It will also depend on coordination of feedstocks and opportunities.

Circular Jobs in Bioeconomy Now

The national baseline analysis found that the bioeconomy generates almost 5,181 indirectly circular jobs (2.5 % of all circular jobs). These circular jobs are all in the agriculture, forestry and fishing sector (SIC 2007 Section A) and in the food and accommodation services sector (SIC 2007 Section I).

This analysis only considers jobs in sectors that interact with primary circular sectors, and is therefore likely to be an underestimation, particularly as it cannot take into account the share of jobs concerned with biodigestion and biorefining which are not currently represented as sectors in the SIC classification. In reality, the bioeconomy includes value capture activities of biobased products such as biodigestion for energy generation and biorefining for high-value chemical production. Please refer to the Annex for information on how employment in the activities discussed below are, or are not, represented in the baseline analysis.

Quantifying circular employment in this emerging area is therefore problematic, as many activities central to the bioeconomy will not be reflected in company or sector data. For example, farms that run an anaerobic digestion plant on site will not be registered as a digestion plant, but rather as a farm.

Future Circular Jobs and Skills in Bioeconomy
Zero Waste Scotland and Circle Economy identified two circular economy strategies in the bioeconomy value chain as being increasingly used in Scotland, or as having significant growth potential for a national circular economy are biorefining and anaerobic digestion (AD). These approaches, the potential roles they generate and the skills required to fill them are outlined below.

Biorefining

Biorefining is the conversion of by-products from biobased sectors into high-value biobased chemicals, proteins, fuels and other biobased materials. In comparison to anaerobic digestion, biorefining produces higher value outputs. Much like anaerobic biodigestion, biorefining strategies tackle the issue of biowaste treatment and demand for fossil-based products. Biorefining can save about 50% of greenhouse gas emissions and reduce demand for fossil fuels by 80% [75].

As yet, the advantage of biorefining lies mainly in its environmental, job creation and innovation potential. The economic feasibility is not yet proven as a consequence of both required investments and low prices of fossil fuel alternatives. At the same time, the production costs for biorefining products are expected to decline rapidly due to optimisation gains and reductions in fossil fuel reserves [76,77]. Developing a biorefining industry has the potential for creating high-value and highly-skilled jobs in rural areas through a system of decentralised production facilities [78,79].

Biorefining is an opportunity area of high interest for Scotland, which as yet is less widely implemented than anaerobic digestion. Biorefining practices need to be scaled up to attain environmental and economic gains by creating more biobased products and related markets [80]. Zero Waste Scotland found that over 27 million tonnes of potential feedstocks for biorefining arise in Scotland every year. This includes waste (mainly animal and mixed food waste), by-products (from the food & drink industry), agricultural residues and wastewater sludge and excludes forestry waste and macro algae [78].

Roles and Skills for Biorefining

Key Takeaways:

- Increase in employment in bio-based product development and manufacturing, requiring highly technical life sciences, biotechnology and bioengineering skills.
- Emergence of specialist roles in sourcing secondary biobased materials for feedstock and new product development, requiring information and management skills.
- Transformation of roles in farms and food producers, requiring knowledge on options and equipment for maximising value from by-products.

There are significant employment opportunities associated with the growth of the biorefining industry, both in relation to the introduction of new technologies and the larger range of products produced from the process. As the biorefining industry grows, so will the range of job opportunities due to the myriad of potential destinations for bioresources, such as the production of healthcare products.

Due to the time restrictions, risks of contamination and precision required to turn by-products from different industries into high-value products, biorefining requires expertise at every stage, from collection and transportation to the processing of by-products. Growth in biorefining capacity will therefore increase the complexity of logistics systems, calling for **harvest operatives, logistics managers** and **supply chain analysts** to ensure that feedstock is consistent and not contaminated or does not have to travel extensive distances. Highly-skilled **biologists, industrial scientists** and **biochemists** are needed to determine applications for outputs of biorefining processes into diverse new products. Alongside this, **quality control managers** and **biochemical engineers** will be vital for ensuring controlled and high-quality processes within plants, utilising their practical experience of working in laboratories and quality control expertise.

Centrally located and regional **bioresource advisors** will work with early adopter food and drink producers already engaged in production of biofuels to explore feedstocks that could be used in the production of high-value chemicals. Within the food and drink industry, the capacity of existing **business leaders, environmental health and safety managers** and **operations managers** needs to be developed. A mindset shift is also required, from viewing the handling of these materials as waste treatment, towards the valorisation of by-products, supported by systems thinking.

Scottish farms currently contribute to the bioeconomy through anaerobic digestion and the circulation and management of nutrient flows. Many farms already use by-products on land or as part of fishmeal. In order to utilise crop and fish farming by-products as high-value sustainable sources of feedstock for biorefining, they should be treated as an additional crop for harvest. **Bioresource advisors** will be needed to identify new routes and opportunities for by-products and in some cases advise farmers on the equipment needed to yield this feedstock. These advisors and **bioresource planners** could also play a role in advising farms on forming cooperatives, in order to collectivise by-products across neighbouring companies to maximise the pool feedstock [75].

The development of a digital marketplace for mapping bioresources on regional and seasonal levels would support these roles and enable **procurement managers** working within biorefineries to identify valuable resources in agri-food. The expansion of biorefining in Scotland would also act as a springboard for employment opportunities in connected industries, such as crops for sugar beet and seaweed, both of which are currently imported [72].

Biochemists, industrial and life scientists

Tasks
- Research and development.
- Overseeing teams of technicians and engineers.
- Adhering to quality guidance and ensuring quality control.
- Maintains robust documentation and batch records.

Skills needs
- Practical laboratory experience, observation and problem recognition skills.
- Up to date methodological knowledge.
- Up to date understanding of regulatory, compliance and quality assurance policies.
- Complex problem-solving, technical skills and initiative.
- Communication skills, ability to lead teams in complex processes.
- Business, commercial and leadership skills.

Relevant qualifications
- First degree, SCQF Level 7-9/10 or advanced qualifications in Life Sciences, Environmental, Material Science, Ecological Sciences or Chemical Engineering SCQF Level 10-12.

Bioresource advisors

Generalist, specialist advisors for advising on agronomics, anaerobic digestion, chemical production, biofuels and other renewable products.

Tasks
- Support and troubleshoot regional farms in the set up, use and maintenance of equipment for anaerobic digestion.
- Identify opportunities for collective and large-scale anaerobic digestion and biorefining, establish collaborations and cooperatives to this end.
- Advising food and drink producers already engaged in biofuels on higher-value options.
- Providing and connecting companies to R&D support for exploring new opportunities and engaging them in regional biorefining processes.
- Keeping abreast of legislation, new policies, technologies and other developments that could impact the value chain.

Skills needs
- Executive management, business and data analysis skills.
- Strong information skills, communication skills and empathy.
- Management and leadership skills, ability to develop and motivate others.

Relevant qualifications
- First degree SCQF Level 7-9/10 or advanced qualifications in Material Science, Ecological Sciences or Environmental Sciences SCQF Level 10-12.

Bioresource planners

Tasks
- Maintaining an overview of the composition and end points of materials in assigned regional farms and food production companies.
- Working with different industries to understand their priorities, processes and by-products.
- Keeping abreast of legislation, new policies, technologies and other developments that could impact the value chain.
- Coordinating with bioresource planners for optimal resource use and redistribution.

Skills needs
- Information skills, with ability to easily sort and filter relevant information.
- Curiosity, monitoring developments in the field.
- Relationship builder, with strong skills for teamworking and collaboration.
- Complex problem-solving, technical skills and initiative.

Relevant qualifications
- First degree SCQF Level 7-9/10 or advanced training in Biology, Material Science or Life Sciences SCQF Level 10-12.

Logistics managers

Tasks
- Oversee the intake of by-products from farms, fisheries, food and drink providers and the distribution of final products to buyers.
- Building and maintaining relationships with internal and external stakeholders to ensure a steady flow of high quality materials.
- Drive new services with logistics service providers to optimise processes.
- Maintain standard operating procedures to ensure quality compliance.

Skills needs
- Experience managing outsourced logistics providers and inter-company relations.
- Analysis, holistic, systems thinking skills.
- Relationship builder, with strong skills for teamworking and collaboration.
- Information and business analytical skills, with ability to easily sort and filter relevant information.
- Complex problem-solving, technical skills and initiative.

Relevant qualifications
- First degree SCQF Level 7- 9/10 or advanced qualification in Supply Chain Management or Business Administration SCQF Level 10-12.

CASE STUDY

Cuantec

Cuantec has developed a prototype of bioplastic from chitin, for use as food packaging. Chitin is the second most abundant naturally occurring biopolymer after cellulose and can be extracted from seafood waste, such as langoustine and crab shells from the food processing industry. Cuantec is also investigating a second value stream, extracting protein from shells for use as high protein feed for fisheries.

The company employs around 14 people with the following roles;

- **Six Scientists** (Bioprocessors, Chemists, Microbiologists). Each team is led by a senior scientist
    - **Processing team [biggest team with three people]:** Extract components for producing chitin from langoustine shell.
    - **Development team:** Developing and converting the chitin into products.
    - **Analytics team:** Run analysis and characterisation of products.
    - **Formulation team (likely to be introduced at a later stage):** Will be responsible for looking at packaging design and product development.
- **Five Directors**
    - **Head of Science:** Manages all scientists.
    - **Board of directors:** Stakeholders in the company with different backgrounds and expertise in food packaging, chemistry, biotechnology and bioprocessing. Have moved more towards business management.
- **Support staff** (Admin; Finance)

The background of Cuantec's researchers is diverse, with experience in the pharmaceutical industry, biodiesel processing, marine biology, microbiology and chemistry. The science park in which the company is located proves to be a good community of small companies working together, networking, and helping each other, with some students joining who have studied at the Scottish Association for Marine Science.

As Cuantec is small in scale and pioneering something which has never been done on a commercial scale before, staff must be inventive, innovative, motivated and perform beyond their role descriptions. Staff possess a problem-solving attitude enabling them to adapt existing equipment used in other sectors for Cuantec's purposes overcoming the lack of research available on deriving the bioplastics from chitin.

CASE STUDY

Rothes CORDe

Rothes CORDe is a biomass-powered Combined Heat and Power (CHP) plant located in Rothes, Scotland. It produces electricity from a combination of whisky distillery by-products and wood chips optimising by-products from the food and drink sector. Additionally, it processes pot ale into feed for livestock, biologically treats effluent waters where sludge is then used for agricultural purposes, and recovers power plant ashes for use as fertilisers on local farm fields. The company works to improve the recovery of protein for animal feed and is currently developing further assets to increase the value of various by-products and sludge from effluent treatment.

Rothes CORDe employs 22 people with a very technical skill-set:

- **Operations Team:** [11 operators, three per shift].
- **Engineers Team:** Maintenance, process development and optimisation.
- **Technicians Operatives:** [e.g. Plant Attendant Department, four people, one per shift].
- **Managers Team:** Managing Director, Plant Manager, Operations Manager, Compliance Manager.
- **Admin Team:** [2-3 people].

The size of the business is the most important differentiator to traditional energy companies, with managers working across departments, requiring them to be multi-skilled. All managers have an engineering background and experience in waste treatment facilities.

Operators and technicians are recruited locally. Operators come from different sectors, while most technicians come from RAF, the army, and the oil and gas sector. All employees undergo a 6-month in-house induction and training programme. There is competition for skilled employees within local industries, including the distillery industry, distillery by-products industry, the energy and the oil and gas sector.

Rothes CORDe focuses on recruiting people with technical competence, a flexible mindset to the work, a safety culture and open communication. The sustainable nature of the business is considered a motivating factor for people wanting to join the organisation.

Anaerobic Digestion

Anaerobic digestion (AD) is a process in which the natural decomposition of biobased materials, such as food waste, is controlled to create biogas and digestate. Biogas is commonly used as a fuel or fed into the gas grid, and digestate is used as a fertiliser.

Biogas can save around 70% of greenhouse gas emissions in comparison to natural gas [81]. However, as producing biogas is also linked with generating greenhouse gases, the environmental impact can greatly vary and processes should be carefully managed, for example, by avoiding leaks and enhancing efficiency [82]. There is a significant initial investment needed for the infrastructure of biodigestion equipment. Small scale, on-site AD plants can bring several economic benefits, including savings in energy and waste management costs, savings in fertiliser use and the sale of excess energy [83]. For large scale industrial biodigestion, the economic benefits vary considerably based on the type and amount of feedstock [84].

An estimated 217 million cubic metres of biogas is produced annually in Scotland. The industrial AD sector in Scotland currently produces the largest share of biogas compared to smaller commercial, merchant plants which use commercial food waste and industrial organic residues. A smaller number of farms also produce biogas through onsite AD, using by-products from their farms or slurry from third parties, often gained through forming cooperatives with other farms in order to pool feedstock [85].

Roles and Skills for Anaerobic Digestion

Key Takeaways:

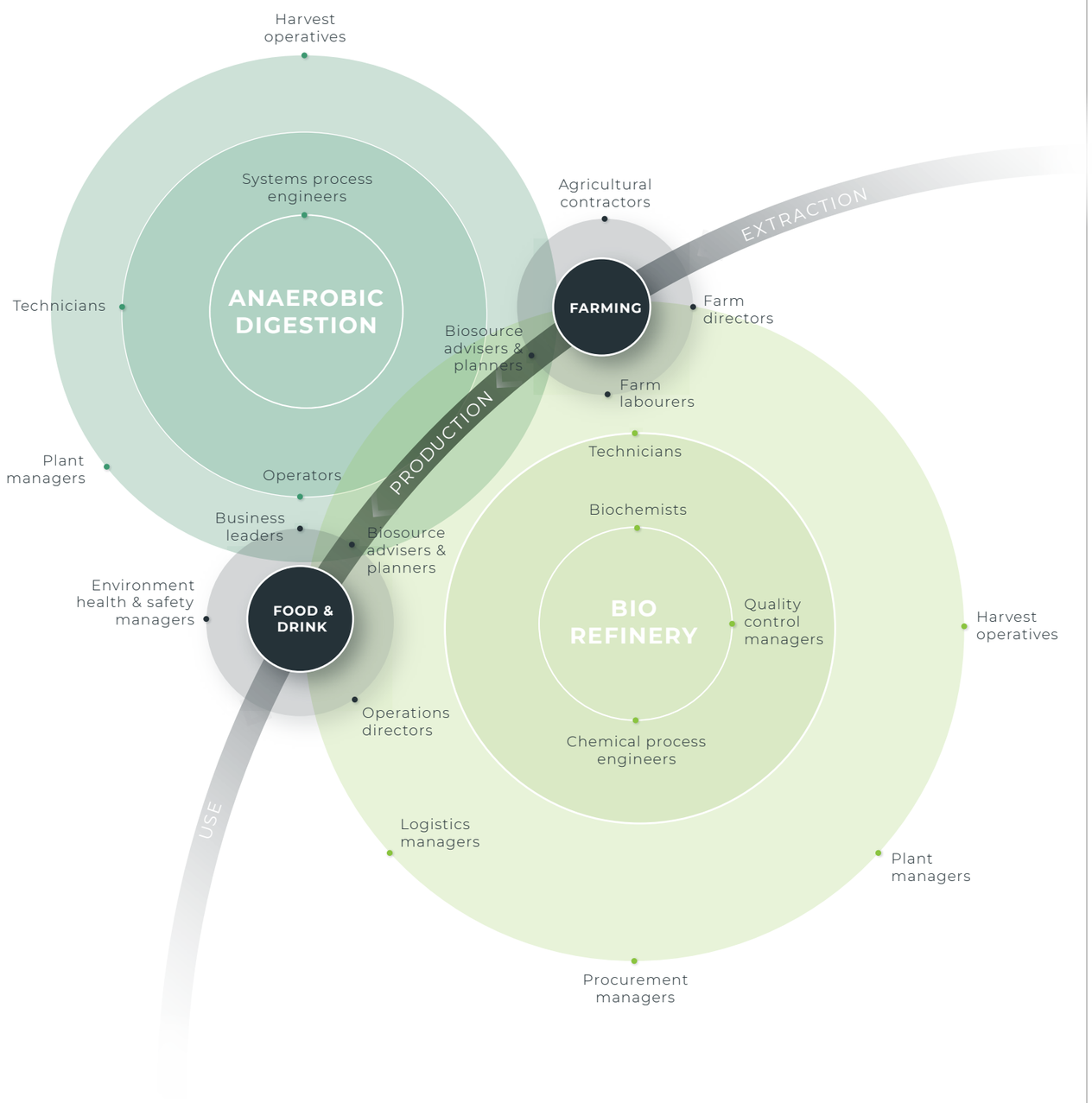
- Increased employment in engineering and technical support in rural areas, requiring technical and manual skills.
- Emergence of roles in the provision of advice and mapping of bioresources, requiring strong information and collaboration skills.
- Transformation of roles in farms and food producers, requiring knowledge on options and equipment for maximising value from by-products.

As well as maximising the opportunities associated with biorefining, Scotland plans to expand the network of AD sites, which could be co-located with biorefining as a side process, or take place at farms or at specialised AD sites. Expansion of AD capacity in Scotland will require a greater number of skilled systems process engineers who will be needed in mostly remote rural areas where these sites will be located, supported by operators, technicians and biogas plant operatives. Considering the lack of skilled engineers that has been cited in the industry and the importance of measures to limit the environmental impact of biogas production, there is significant employment potential for engineers to work both in industrial plants and in a growing number of merchant AD sites that take commercial and household food waste [81,85]. Large-scale biodigestion will call for an increasing number of process operatives and technicians, as well as roles in sales and innovation needed to grow the market for AD products.

Significant volumes of biogas potential in the form of by-products from food, drink and agriculture are currently lost or discharged to sea. Farm directors will need to be encouraged to develop a greater awareness of the value of by-products for producing energy through onsite AD facilities and the benefits of co-digestion, supported by regional specialist bioresource advisors. Bioresource advisors specialised in working with the agricultural industry will also be required to support on-farm staff with better understanding the AD process and providing advice and training on equipment that can be used to make the process more efficient in-house. There will also be a need to support farms in utilising digestates, the biodegradable materials produced from the AD process, for agronomic benefits such as soil health. Recovering high-value nutrients from digestates is currently an underexplored area, which presents employment opportunities for biologists and ecologists for finding alternative uses for digestates.

Farms, food and drink producers which have already diversified into AD could act as ambassadors and demonstrators to other parts of the sector wanting to move into this area. Here farms could also act as educators to the public through agri-tourism, teaching visitors about the environmental improvements being implemented by the agri-food sector and how by-products from the production of food can be used to create additional value.

Bioeconomy



Skills Pathways for the Bioeconomy

1. Promote employment opportunities in the bioeconomy

- Raise awareness of the circular economy amongst the board, senior management and finance directors of agri-food producers. These professionals will need to understand the value of bioresources and how to access this value from their waste streams. This should start with upskilling.
- Early adopter businesses who can act as ambassadors of the bioeconomy will be key to encouraging steps to be taken by others. Particularly for the agricultural industry, agri-tech innovation centres or fully functioning demonstrator farms will be important for transferring knowledge of AD and biorefining.

2. Translate opportunities into new career destinations for graduates

- There is currently a shortage of technicians and bioengineers with adequate experience in areas like laboratory working, quality control and commercial business. The combination of skills required in the circular economy is also not always obvious, for example, the knowledge of waste streams in combination with chemistry for working in biorefining. Graduates need support in seeing how their qualifications fit in the circular economy. This is particularly the case for graduates with chemistry degrees, who may not see biorefining as a career option. Similarly, professionals in more traditional areas of the chemical industry require clearer pathways into the circular economy.
- As the industry grows, these career destinations can be illustrated by creating case studies and job profiles that clearly illustrate the combination of skills required and providing practical industry-facing courses, as is being encouraged by The Industrial Biotechnology Innovation Centre (IBioIC) and currently modelled by Lantra for agriculture, forestry and fishing [86].

3. Manage the urban-rural divide of life sciences skills

- New technologies may disrupt the existing geographical distribution of industries. However, many roles in the bioeconomy will still need to be based close to bioresources. Although Scotland has a strong record in life sciences and a robust skills pipeline in this regard, there may be challenges in matching these skills to rural employment opportunities, where plants may be located, but where historically high-value sectors may not have been located.
- Locations for biorefining and other high-value areas of the bioeconomy therefore need to be made attractive to work and create jobs for people in the communities where they are situated in order to ensure the growth of the bioeconomy is inclusive to workers in all areas of the country, including women and young people.

4. Build in workforce mobility and transferability of skills

- As industries shift and new markets open up through advances in technologies and materials, it will be increasingly important that workers have transferable skills to enable them to move between industries. This means flexibility should be encouraged in the workforce so that skills developed now can be applied to the different directions in which the bioeconomy sector may grow. Mobility of workforce and transferability of skills is particularly key to emergent sectors like the bioeconomy, where the business landscape will look very different in 10 years.

Realising the Opportunities for the Scottish Labour Market

Unlocking the labour market potential of the circular economy across sectors can only be realised if the right enablers are in place. Key enablers include circular design, circular procurement, and recycling infrastructure and services. Fundamental changes are needed in all these areas to accelerate the implementation of the circular economy. These changes will also have implications for education and skills requirements.

Design

Waste is a design flaw. In design, important considerations and decisions have to be made with the whole life-cycle in mind: how a product is manufactured, how it is used, and what happens when it is no longer needed or wanted. If it cannot be repaired, remanufactured, refurbished or even recycled easily or in a cost-effective manner, it will end up in landfill and a new item has to be bought. Without changes to how we design products, buildings, business models and cities, we will not be able to decouple economic growth from resource consumption, drive innovation and open up new markets. We will continue to lose the enormous amount of embedded materials, energy, water and labour that cannot be harnessed through repair, refurbishment, remanufacturing, disassembly, deconstruction and recycling. The economic potential of resources cannot be optimised.

The importance of circular design is a theme cutting across all value chains. Key elements include material selection, standardised components and designing not just for use but for deconstruction, disassembly, remanufacture and recyclability. These require advanced skills, information sets, and working methods.

The main issue, however, is that circular design will not become mainstream without demand.

To embed circular design, actors along the value chain - including building users, investors and regulators - need to engage in the process For truly sustainable and circular design, total life cycle costs and financial and non-financial returns on investments need to be considered [87]. In all parts of the value chain, workers need the right knowledge, skills and mindset.

Sumter et al. (2020) have identified seven competencies relevant in the context of circular design [88]:

1 Circular Impact Assessment: Estimating the environmental impact of circular offerings on a system level over multiple use cycles to support decision-making during the design process.
2 Design for Recovery: Incorporating recovery strategies during the design process while taking into account multiple use cycles.
3 Design for Multiple Use Cycles: Foreseeing the consequences of prolonged use and multiple use cycles.
4 Circular Business Models: Concurrently developing the circular product, service, and business model.
5 Circular User Engagement: Engaging users in the use and the (end-of-use) return of products.
6 Circular Economy Collaboration: Identifying, mapping, facilitating, and managing the collaboration between external stakeholders in operationalising a circular business model.
7 Circular Economy Communication: Telling coherent stories about the circular offerings.

Private and Public Sector Procurement

Circular business models and products will only become mainstream if there is adequate demand for circular products, buildings and cities. Low demand and supply will otherwise result in a self-perpetuating cycle. Changing the demand side of the market will support innovation and underpin investment within the private sector to create commercially viable circular business models and products.

Procurement defines how we demand products and services. It is estimated that procurement spending across the public sector in Scotland is in excess of £11 billion each year (10% of Scotland's Gross Domestic Product), generating around £10 billion of economic activity in the wider Scottish economy and supporting around 100,000 jobs (FTE), both directly and indirectly [89].

Procurement is therefore not only a powerful tool to contribute to Scotland's economy, but the associated investment can also be directed in a way which delivers the most benefit to our society and environment. Integrating circular economy criteria into public and private procurement actively contributes to promoting services over ownership. Prioritising reuse, repair and remanufacturing of assets is an important enabler for transitioning to a circular economy and addressing the climate emergency. Zero Waste Scotland's 'Procuring for: Repair, Reuse & Remanufacture' report [90] identified 13 categories and commodities that the public sector procures where circular economy options exist. Analysis of spend data indicated these categories have a total value of £1.1 billion.

Recycling Infrastructure and Services

Without the right waste and recycling infrastructure or standardisation in recycling collections, end of life products and materials cannot be dealt with appropriately and the commercial viability of recycling operations is reduced. This impacts profoundly on our ability to meet recycling targets, strengthen resilient local materials supply chains and retain the value of materials within Scotland.

Scotland is working to reduce waste production and increase recycling rates. By 2025, the Scottish Government aims to reduce total waste arising in Scotland by 15% against 2011 levels; reduce food waste by 33% against 2013 levels; recycle 70% of remaining waste and send no more than 5% of remaining waste to landfill. Scotland is also committed to matching the EU ambition to make all plastic packaging economically recyclable or reusable by 2030. Making Things Last, Scotland's circular economy strategy, sets out how Scotland will aim to achieve these targets [7]. But more needs to be done. The Scottish Government held a Recycling Summit in December 2019 to discuss with a range of stakeholders how best to achieve these ambitious targets. Additionally, the Household Recycling Charter agreed by the Scottish Government and CoSLA aims to increase the consistency of household recycling services [91].

In 2018, Scotland's household recycling rate was 44.7% and that of waste from all sources 60.7%, a decrease of 0.9% and increase of 1.1%, respectively, from 2017 [92,93]. The Scottish Landfill Tax and the impending biodegradable landfill ban underpin these efforts. However, in 2018 Scotland still exported 1,662,903 tonnes of waste [94] and more reprocessing capacity needs to be developed.

Improving recycling makes economic sense for certain materials.

Recycling operations can only be established and maintained if they are commercially viable. This is dependent, among other things, on the volume and quality of inputs. A lack of clear guidance for recycling of construction and demolition waste is a barrier especially to smaller companies [95].

As indicated by the Scottish Government [96], when the ban on the disposal of biodegradable municipal waste takes effect, which has now been postponed to 2025, there will be insufficient treatment capacity available in Scotland to receive the material diverted from landfill. Alternative treatment and disposal routes are therefore sought outside of Scotland.

In 2019, SEPA determined waste management infrastructure capacity requirements for the Scottish Government's Circular Economy Strategy for Scotland, Making Things Last [97]. It shows that additional waste management capacity of 2,060,000 tonnes is required. 960,000 tonnes of this additional capacity is needed to manage source segregated recyclables and 1,100,000 tonnes additional capacity is needed to manage unsorted waste. Waste prevention through the implementation of the circular economy could help reduce the need for some of this capacity.

CASE STUDY

BINN Group

Set up 20-years ago, BINN Group has evolved from a landfill-based company to one primarily involved in the collection and sorting of commercial and industrial waste, with some domestic waste collection from household skip hire. Waste is sorted and recyclables are bulked and sent for reprocessing. 14% of residual waste is used for the onsite manufacture of Solid Recovered Fuel (SRF) and some is sent to a nearby Waste-to-Energy (WTE) plant. Landfill is used for hazardous waste like asbestos. BINN Group has a 90% recycling and recovery rate.

Today, BINN Group has a fleet of about 50 vehicles to collect waste and 62 acres of land to process and recycle waste. They directly employ over 130 people, many from local communities, and run waste training for their staff. A large proportion of employees are site-based operators sorting, separating, bailing and processing waste.

Over the years, the company has witnessed significant changes in roles. The introduction of the Material Recycling Facility caused a decrease in the number of drivers and office staff and an increase in technicians operating different facilities on site. In the future, the company sees this trend continuing with more opportunities for operators to work at different plants. Nevertheless, the UK has a skills gap of Class 1 and 2 drivers which impacts the resource management sector.

The Covid-19 pandemic highlighted the role of waste collection and drivers who were hailed as key workers raising the profile of the waste industry. Specifically, due to the reduction in staff numbers, BINN Group expects the future focus to be on job sharing, transferability of skills, and training individuals, as roles diversify, and responsibilities widen.

The company realises the role its collectors and drivers play in educating the public about waste segregation within the workplace coupled with a certain degree of maintaining customer service. They are the face of the company. BINN Group believes the integration of advice and customer service will continue to develop as the types and amount of waste streams that are collected may evolve over time.

At BINN Group, the focus on circular economy principles supports the attraction of better talent. Circular economy principles are embedded in the vision, values and mindset of the organisation.

Conclusions

The sectors and circular strategies explored in this report can deliver environmental and social benefits for Scotland by building on the existing strengths and the foundation of skills in the Scottish economy. These jobs, business models and networks can help Scotland become less resource-dependent, reduce offshoring of our emissions, and support the labour market. To realise these opportunities - and their potential to help deliver the Green Recovery which Scotland needs - the right incentives, skills strategies and policy interventions must be in place.

The circular economy will have an impact across sectors, increasing demand for existing roles, such as those in resource management, logistics and engineering, while other existing roles will be transformed. It will also create demand for different combinations of skills and ways of working. This will bring a need for a wide range of occupations and skill-sets presenting job opportunities for all types of workers from low and medium-skilled to highly-skilled. To develop the required skill-sets for new future roles such as urban miners, the circular economy must be embedded into all skills, education and lifelong learning systems. The transition to a circular economy creates the need for gradually evolving skills, mindsets and behaviours, which will require some different approaches, training programmes and business models to be created and incorporated into existing workforce planning and development practices.

As the skills pathways within this report demonstrate, there is a strong need for digital skills development, particularly in the construction sector. This can maximise the potential of technologies to improve communication, collaboration and material efficiency, all central to the circular economy. Maximising the promising future of the bioeconomy will require work to raise awareness of the significant business and job opportunities it brings to turn waste streams into value and make this emerging sector a mainstream career choice for graduates. Meanwhile there is a valuable window of opportunity to grasp the varied redeployment options which decommissioning of oil rigs and wind turbines in Scotland's energy sector presents.

As industries shift and new markets open up through technological advances and improved materials, workers need to develop transferable meta-skills, such as adaptability and holistic thinking, to be able to move across industries. Meanwhile, existing key legacy skills must also be harnessed and not lost, particularly in the energy sector, to ensure a just transition to a circular economy. This is even more important in light of the significant negative economic impacts of the COVID-19 pandemic and Brexit.

If managed through the lens of a just transition, the circular economy can help to address some of the existing social inequalities exacerbated by the current wasteful linear economic system, Brexit and the COVID-19 pandemic. This should complement changes already being made to recruitment strategies and workforce development to address Scotland's ageing workforce, the need for access to flexible working for all and the encouragement of young people, especially women and people from Black, Asian and Minority Ethnic (BAME) groups, into STEM (Science, Engineering, Technology and Maths) related sectors and careers, in line with Scottish Government policy.

All these opportunities require improvements in resource management infrastructure, the integration of circular economy principles in private and public sector procurement, and the development of digital skills across Scotland.

Circular products and services will never become mainstream unless demand rises. The public sector can lead the way in driving that demand, backed by policies supporting the national switch to circular products and services.

Employers, the business community and industry can lead the way in workforce planning through skills development and circular innovation.

This report will also help inform the Scottish Government's goal to promote a Green Recovery by placing circular economy skills development and jobs at the heart of ongoing work to 'Build Back Better' to overcome both COVID-19 and the climate crisis.

Contacts

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Further information on all Zero Waste Scotland's programmes including circular economy support and advice for new and existing businesses can be found at www.zerowastescotland.org.uk.

Further information on Circle Economy's Circular Jobs Initiative can be found at www.circle-economy.com/circular-jobs-initiative.

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Annex: Methodology

1. Data Sources and Territorial Units

The baseline analysis utilised 2016 Business Register and Employment Survey (BRES) employment data [19]. In line with this employment data, the regional results are discussed in this report and displayed on Circle Economy's Circular Jobs Monitor according to Eurostat's Nomenclature of Territorial Units for Statistics (NUTS) 2013, which distinguishes between four regions in Scotland at NUTS 2 [20]. These are Eastern Scotland (Angus and Dundee City; Clackmannanshire and Fife; East Lothian and Midlothian; Scottish Borders; City of Edinburgh; Falkirk; Perth & Kinross and Stirling; and West Lothian), South Western Scotland (East Dunbartonshire, West Dunbartonshire and Helensburgh & Lomond; Dumfries & Galloway; East Ayrshire and North Ayrshire mainland; Glasgow City; Inverclyde, East Renfrewshire and Renfrewshire; North Lanarkshire; South Ayrshire; South Lanarkshire), North Eastern Scotland (Aberdeen City and Aberdeenshire) and Highlands and Islands (Caithness & Sutherland and Ross & Cromarty; Inverness & Nairn and Moray; Badenoch & Strathspey; Lochaber, Skye & Lochalsh, Arran & Cumbrae and Argyll & Bute; Eilean Siar (Western Isles); Orkney Islands; Shetland Islands).

2. Definition of a Circular Job

Previous studies have put forward an initial understanding of which sectors contain circular jobs. However, these studies largely incorporate only end-of-life aspects of the circular economy as it relates to waste management, and additional aspects of the circular economy need to be considered [98].

CIRCULAR JOB	ECONOMIC SECTOR	CIRCULAR ECONOMY ELEMENT	EXAMPLE SECTORS AND ACTIVITIES
DIRECT CIRCULAR JOBS	CORE SECTORS	Sustain and Preserve What's Already There Use Waste as a Resource Prioritise Regenerative Resources	Repair Services Recycling Renewable Energy
	ENABLING SECTOR	Design for the Future Incorporate Digital Technology Rethink the Business Model Team up to Create Joint Value	Industrial Design and Architecture Digital Technology Renting or Leasing Activities Professional and Networking Associations
INDIRECTLY CIRCULAR JOBS	INDIRECTLY CIRCULAR SECTORS		Education Government Services Professional Services

Table 1: An indication of how sectors are mapped to the DISRUPT Framework

A piece of work by Circle Economy, Making Sense of the Circular Economy: The 7 Key Elements [18], constituted a literature review and mapped the various terms and definitions used by over 20 organisations - NGOs, government agencies, academia, consultancies, etc - working on the circular economy. From this work emerged a framework for the circular economy - the DISRUPT Framework, and from this framework the description of a circular job was formulated.

The DISRUPT framework defines three core strategies, intervening directly in material stocks and flows, and four enabling elements which relate to technology, collaboration, design and business models to support, scale up and mainstream the core strategies.

A circular job is any occupation that directly involves one of the elements of the circular economy or indirectly supports such activities. A directly circular job includes jobs that follow core and enabling circular economy elements. An indirectly circular job includes jobs within all other sectors of the economy that support the directly circular jobs.

Using this definition of circular jobs, the sectors of economic activity as defined by the UK Standard Industrial Classification (SIC) 2007 are classified as core circular, enabling circular, or indirectly circular, based on how well the sectors are connected to the DISRUPT Framework. An indication is provided in the table below, followed by a full extract of SIC level 5 sectors mapped to the DISRUPT Framework.

DISRUPT Element	Corresponding SIC (2007) 5-digit level
Sustain and Preserve What's Already There	33100; 33110; 33111; 33112; 33120; 33121; 33130; 33131; 33140; 33141; 33150; 33151; 33160; 33161; 33170; 33171; 33190; 33191; 45112; 45192; 45201; 45202; 45204; 45205; 45206; 45402; 47790; 47791; 47792; 47793; 95000; 95100; 95110; 95111; 95120; 95121; 95200; 95210; 95211; 95220; 95221; 95230; 95231; 95240; 95241; 95250; 95251; 95290; 95291; 95292; 95299
Use Waste as a Resource	36000; 36001; 36002; 36003; 37000; 37001; 37002; 37003; 38000; 38100; 38110; 38111; 38112; 38120; 38121; 38200; 38210; 38211; 38212; 38213; 38219; 38220; 38221; 38222; 38300; 38310; 38311; 38312; 38320; 38321; 38322; 38323; 38329; 39002; 43110; 43111; 46770; 46771; 46772; 46779
Prioritise Regenerative Resources	3511X[12]
Design for the Future	71110; 71111; 71112; 71120; 71121; 71129; 74100; 74100; 74101; 74102; 74103; 74104; 74105; 74109
Incorporate Digital Technology	61000; 61100; 61101; 61200; 61201; 61202; 61300; 61301; 61900; 61901; 62000; 62010; 62011; 62020; 62021; 62030; 62031; 62090; 62091; 63100; 63110; 63111; 63120; 63121; 63900
Rethink the Business Model	43996; 77200; 77210; 77211; 77212; 77213; 77220; 77221; 77290; 77291; 77292; 77293; 77294; 77295; 77296; 77299; 77300; 77310; 77311; 77320; 77321; 77330; 77331; 77340; 77341; 77350; 77351; 77390; 77391; 77392; 77393; 77394; 77399; 96010; 96011; 96012; 96013; 96014; 96015
Team up to Create Joint Value	94100; 94110; 94111; 94120; 94121; 94200; 94201

Table 2: SIC Codes mapped to the DISRUPT Framework

[12] The Renewable Electricity Production Sector Codes at NACE Level 5 are not standardised, therefore bottom up data is used to establish proxy codes of 35111 - Production of Non Renewable Electricity, and 35112 - Production of Renewable Electricity.

3. Quantifying Circularity

Core Circular Sectors

For core circular strategies it is assumed that 100% of the jobs are circular. In order to predict the share of employment in the renewable energy sector an additional step is undertaken to estimate this separately. This is because even the most granular employment data rarely discerns between renewable and non-renewable energy employment. To this end, the International Renewable Energy Agency (IRENA) dataset on national employment in the renewable energy sector is used to gather total employment figures (direct and indirect jobs) at the country level per renewable energy technology. Based on external sources [99], we assume an average 50% for splitting direct and indirectly circular jobs. Following this, the national proportions of direct renewable energy employment per technology over total energy employment are applied to the regional data to estimate the number of direct regional jobs in the renewable electricity sector. This number is subtracted from the total employment number for energy and made explicit in the raw employment data. Finally, the number of indirectly circular jobs related to renewable electricity is endogenously estimated by the Input-Output model.

For the purposes of this report, a further step was taken to split out jobs associated with non-circular activities in the resource management sector.

Zero Waste Scotland distinguishes between circular treatment of waste, which includes all activities that recycle materials, and non-circular treatment of waste, which includes the recovery of other value and disposal of waste (landfill and incineration with and without energy and heat capture). This is reflective of different levels of value capture in the waste hierarchy [100]. Whereas recycling and any waste treatment methods higher up the waste hierarchy are considered circular, anything lower is not. There is a general consensus that activities higher up in the waste hierarchy are more labour intensive than activities lower in the hierarchy. The exact difference in labour intensity though, is highly complex to calculate, heavily dependent on technological progress and therefore highly contested.

The resource management sector can be split into the collection activities and treatment and disposal activities. Jobs related to incineration and landfilling activities were subtracted from the total number of jobs initially calculated as core circular jobs using the above method. The number of jobs involved in incineration and landfilling activities were estimated based on waste data retrieved from SEPA and employment multipliers obtained from Eory [101]. From the 17,360 core circular jobs in resource management (SIC 2007 Section E) of the initial calculation, a closer analysis shows that 14,807 contribute to the circular economy when excluding incineration and landfilling activities. This is the result of removing jobs related to the collection of residual waste and incineration and landfilling activities for the initial calculation. An estimated 2,158 jobs relate to the collection of residual and therefore non-recyclable waste. This is based on a total of 3.6 million tonnes of residual waste collected in Scotland on an annual basis, with an average of six jobs created per 10,000 tonnes per annum. Another 395 jobs relate to incineration and landfilling activities. This is based on 3.8 million tonnes of waste going to landfill and 200,000 tonnes of waste incinerated in Scotland per year. Both activities involve an average of one job per 10,000 tonnes per annum. Note that this estimate still includes jobs in recycling of construction materials, which is mostly downcycled and the level of circularity, here too, is questionable [101].

Enabling and Indirectly Circular Sectors

For the enabling circular and indirectly circular sectors, however, not all jobs are circular and it was necessary to analyse what percentage of the jobs within these sectors can be considered circular. This analysis is done through the use of Input-Output Tables (IOTs).

IOTs describe the economy as an integrated system of monetary transactions among industries, consumers and capital, with rows representing the 'source' of activity (industry output or supply) and columns representing the 'destination' (industry input or demand). The sectors in the rows and columns are classified using the SIC mapping indicated above. For an exhaustive theoretical background on IOTs and Input-Output Analysis (IOA), please refer to Miller and Blair (2009) [102]. Generally, IOTs are produced by National Statistical Institutes (NSI) and are therefore at the national level. Whenever the scope of the analysis is at a lower geographical level, i.e. regional or urban, the Spatial Microsimulation Urban Metabolism (SMUM) model by UNEP is used to downscale the intermediate demand matrix based on sector-specific employment data [103].

Sector classifications can vary greatly between different IOTs. Most tables are specified at SIC level 2 or similar, as opposed to SIC level 5 as per the classification table. Because sectors at SIC level 2 are still quite broad and incorporate many sub-sectors, they can often be intended as a combination of core, enabling and indirectly circular industries. In order to distinguish between sub-sectors, corresponding proportions must be applied to every row and every column to disaggregate the broad sectors, thereby exposing fully core, enabling and indirectly circular sectors. We calculate these proportions using granular employment figures at SIC level 5 and applying it to each SIC level 2 sector. This transformation is displayed in the image below where Table 3 is transformed into Table 4.

	Sector **B**
Sector **A**	100

Table 3: Subset of Original IO Table

	Sector **B** Core	Sector **B** Enabling	Sector **B** Indirectly
Sector **A** Core	10	5	0
Sector **A** Enabling	5	50	20
Sector **A** Indirectly	0	10	0

Table 4: Subset of Original IO Table with Circular proportions applied

Once the original table has been disaggregated to SIC level 5, we can determine the share of circular activity within a particular enabling or indirectly circular sector. The estimation of such circular employment shares is based on the inter-industry relationships between sectors and on the assumption that monetary transactions in the form of supply and demand of products/services are a proxy for employment generation. The estimation of circular employment shares follows two slightly different logics for enabling and indirectly.

For enabling sectors, we assume that the extent to which they can be considered circular is determined by the share of supply (output) of enabling products/services to core sectors over the total supply of enabling products/services. This can also be thought of as the (circular) market share of enabling to core sectors over the total enabling output. For indirectly circular sectors, we assume that the extent to which they can be considered circular is determined by the share of demand (input) of indirectly circular sectors for core product/services over the total demand of indirectly circular sectors. This can also be thought of as the (circular) input coefficient of indirectly circular sectors from core over the total input of indirectly circular sectors. Noticeably, we do not consider the interaction between enabling sectors to classify as circular. The figure below presents a case-by-case graphic depiction of the logic.

[13] 3.6 million tonnes of residual waste may be an overestimation as the tonnages are double counted where waste is initially taken to a site, to then be moved to another. This is, however, not necessarily a problem as these tonnages are used to calculate related employment.

Core Circular Sectors Logic

	Core	Enabling	Indirectly	
Core	A	B	C	Total Core Outputs
Enabling	D	E	F	Total Enabling Outputs
Indirectly	G	H	J	Total Indirectly Outputs
	Total Core as Inputs	Total Enabling as Inputs	Total Indirectly as Inputs	

Core	**100%**
Enabling	
Indirectly	

Enabling Circular Sectors Logic

	Core	Enabling	Indirectly	
Core	A	B	C	Total Core Outputs
Enabling	D	E	F	Total Enabling Outputs
Indirectly	G	H	J	Total Indirectly Outputs
	Total Core as Inputs	Total Enabling as Inputs	Total Indirectly as Inputs	

Core	
Enabling	**D/(Total Enabling as outputs) = X%**
Indirectly	

Indirectly Circular Sectors Logic

	Core	Enabling	Indirectly	
Core	A	B	C	Total Core Outputs
Enabling	D	E	F	Total Enabling Outputs
Indirectly	G	H	J	Total Indirectly Outputs
	Total Core as Inputs	Total Enabling as Inputs	Total Indirectly as Inputs	

Core	
Enabling	
Indirectly	**C/(Total Indirectly Outputs) = Y%**

The result of these operations are three matrices, one for each category, filled with coefficients ranging between 0 and 1; the product of these matrices is a single final circular coefficient matrix (C) which reflects the share of each transaction (and assuming full proportionality, also jobs) that can be considered circular.

We move on by applying standard IO formulas for the calculation of the total industry output (x vector), Intermediate coefficient matrix (A matrix) and Leontief inverse or total requirement matrix (L matrix). Each element of L is also known as total requirement multiplier:

$$x = Zi + Yi$$

$$A = Z\,\widehat{x^{-1}}$$

$$L = (I - A)^{-1}$$

Where Z is the intermediate demand matrix, Y is the final demand matrix, i is a summation vector, x^{-1} is the diagonalised inverse of the total output and I is the identity matrix with same shape of A.

We then apply the circular coefficients to the Leontief inverse by multiplying the two and create a new counterfactual matrix which only considers the circular share of each total requirement multiplier, that is the "circular" requirement multiplier:

$$L^c = L\,C$$

Where C is the circular coefficient matrix and L^c is the counterfactual Leontief inverse matrix. Finally, we apply the standard IO formula for calculating the total stressor in a system:

$$E = b'\,\widehat{L^c Y}\,\iota$$

Where b' is the row vector of employment intensities (number of FTE jobs per unit of sector output), L^c is the counterfactual circular requirement matrix , Y is the final demand matrix, i is a summation vector and E is the matrix of circular employment by sector.

4. Advantages and Limitations

The approach holds advantages and limitations:

- The method employs macro-economic data, which is up to date, reliable and existing data to calculate the amount of jobs in the circular economy. There is no need to collect new data, a time intensive and costly process.
- This data is structured following the SIC 2007 an internationally standardised classification system. This allows for replication and comparison of results over time and across borders.
- The method employs a proxy to calculate the circular share of jobs in enabling and indirectly circular sectors. This proxy is derived from economic interaction between sectors (see method description IOA above) and can therefore lead to an under or overestimation of circular jobs in enabling and indirectly circular sectors.
- The method consists of an original application of IOA, which has to date not been validated by a larger scientific community and therefore still highly uncertain. Additionally, the method inherits all the assumptions and constructs behind the production of IOTs [102].
- The method scales down and aggregates employment data based on monetary information. The relationship between employment and monetary transactions rests on the following assumptions:
    - Employment is a good proxy for downscaling national IOTs to lower geographical scopes.
    - Employment is a good proxy for disaggregating sectors in IOT, which implies full proportionality between monetary transactions and employment.
    - Volume of monetary transactions is a good proxy for estimating the number of jobs (for the estimation of circular market shares and input coefficients), which again implies full proportionality between monetary transactions and employment.
- The method takes into account only domestic flows and therefore does not account for circular employment implications related to trade with other countries (import and export).
- The energy sector split is based on average national data on renewable energy employment and, as such, it does not capture inter-regional differences in renewable energy employment. As a consequence, circular employment in the energy sector will be underestimated in regions with a larger concentration (above national average) of renewable energy plants.
- The method maps jobs according to where companies were registered and therefore cannot represent the exact geographical location of jobs for companies that have multiple locations.

Considering both the advantages and limitations, the method employed for this report forms the basis - and first iteration - of a monitoring practice for employment in the circular economy.

5. Updates to the Methodology

With the aim of continuous improvement in monitoring jobs in the circular economy, Circle Economy updates its methodology for quantifying circular economy jobs on a yearly basis. It therefore follows that in some cases the results shown in reports using previous versions of the methodology may differ from the ones displayed on the online Circular Jobs Monitor. In these cases, we include a method update notice on the landing page of all relevant reports.

6. Circular Jobs by Sector

The table below displays the number of circular jobs per sector and the number of circular jobs as a percentage of the total number of jobs in each sector, as according to SIC 2007. These results can also be accessed via Circle Economy's Circular Jobs Monitor.

Sector	# of circular jobs in sector	% of total jobs in sector
A Agriculture, forestry and fishing	1,392	2.8%
B Mining and quarrying	1,547	5.2%
C Manufacturing	19,451	11.1%
D Electricity supply	4,949	26.0%
E Waste	17,360	100%
F Construction	3,752	2.8%
G Wholesale and retail trade	9,504	2.7%
H Transport and storage	1,938	1.8%
I Accommodation and food service activities	3,789	2.1%
J Information and communication	45,709	62.6%
K Financial and insurance activities	1,176	1.4%
L Real estate activities	201	0.6%
M Professional, scientific and technical services	32,538	19.1%
N Administrative and support services	10,542	5.8%
O Public administration and defence	9,834	6.3%
P Education	5,347	2.8%
Q Human health and social work activities	24,449	6.0%
R_S Arts, entertainment and recreation, Other services activities	13,949	10.9%

7. How Employment in Circular Activities is Captured in the Baseline Assessment

SIC 2007 is the standard industry classification system for the UK. The circular activities identified within the three key value chains in this report do not fit this classification system in all cases. This has implications for how well employment associated with these activities is represented in the baseline analysis.

This section describes how the eight circular economy strategies discussed in this report are, or are not, represented in the initial baseline analysis.

7.1 Construction

Offsite Construction

Jobs in offsite construction are not captured in a separate sector or counted in the model as directly circular and may also be captured within the manufacturing sector. Most of these jobs are therefore not represented in the assessment above. As this is a very small sector this does not have a significant effect on the results.

Closed-loop Cycling of Building Materials and Components

Jobs related to closed-loop cycling of building materials and components are captured in the waste management sector (SIC 2007 Section E), specialised construction activities (SIC 2007 43.11) and an additional small share in construction companies (SIC 2007 Section F), as indirectly circular jobs.

Digitisation of Buildings and Material Management

Jobs in digitisation of material tracking as well as design activities around this are included in the estimation above through the enabling Design for the Future and Incorporate Digital Technology principles.

Based on the three strategies put forward above, the estimation model is a marginal underestimation of jobs related to the circular economy in the construction sector.

7.2 Capital Equipment

Reuse and repurposing

Jobs related to reuse and repurposing are registered under the installation sector (SIC 2007 33.20), and partially in the extraction sector (SIC 2007 06), as some firms will specialise and others will internalise these activities. Neither of these sectors are considered directly circular, and therefore only marginally counted as indirectly circular jobs. The model therefore underestimates the circular jobs related to reuse and repurposing.

Remanufacture and Refurbishment

Jobs in the remanufacturing industry are captured in the manufacturing sector (SIC 2007 Section C) as enabling and indirectly circular jobs.

Product-as-a-Service Models

Jobs related to rental and leasing models are captured in the rental and leasing sector (SIC 2007 77), and all counted under the Rethink the business model principle. The estimation above correctly reflects the jobs created in product-as-service models.

7.3 Bioeconomy

Biorefining

There are currently far fewer jobs related to biorefining in Scotland than to anaerobic digestion. Much like anaerobic digestion, these jobs are captured in the waste management sector (SIC 2007 38.21) and captured under the Use Waste as a Resource strategy. As this is an emerging sector, some jobs relate to research and development. These would be registered under the scientific research and development sector (SIC 2007 72.11), and therefore counted as indirectly circular jobs.

Anaerobic Digestion

Small scale on-site anaerobic digestion jobs are registered under the agriculture sector (SIC 2007 Section A) and the waste management sector (SIC 2007 38). These are respectively captured in the estimation above as indirectly circular jobs and under the Use Waste as a Resource strategy. Industrial scale anaerobic digestion is registered in the waste management sector (SIC 2007 38.21) and as such the related jobs are captured in its entirety under the Use Waste as a Resource strategy.


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