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Sustainable Consumption: A review of Circular Economy policies in principle and practice

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Summary

Our current global industrialised economy is based on a linear “take, make, dispose” model, in which raw resources are extracted from nature, turned into products, then disposed of when no longer wanted or no longer functional. This model is unsustainable and has significant environmental consequences.

In contrast, circular economies follow the 4R framework, in which products and resources are Reused, Remanufactured, Recycled or Recovered wherever possible. In so doing, circular economies keep products and resources circulating through the economy for as long as possible, reducing the need to extract resources from nature. This aims to minimise waste, reduces the global footprint of human consumption on the environment, and reduces costs for companies and consumers.

The purpose of this report is to explain what a circular economy is, and to provide examples of potential policy interventions governments could take to increase the circularity of their economies.

The report includes an explanation of the take-make-dispose economic model and its drawbacks, followed by an introduction to what a circular economy is, and how it can solve many of the problems our economies currently face.

It then provides real examples of policy interventions or actions undertaken or supported by governments in different countries to move towards a more circular economy. Four different policy interventions are discussed which were chosen to cover a broad range of different types of policy intervention which are possible:

- Deposit Return Schemes which incentivise consumers to change their behaviour.
- Government establishment and facilitation of Industrial Symbiosis Programmes which increase the efficiency of resource use in industry.
- Legislation requiring businesses to adopt circular economy principles.
- Government support and advice for a trial scheme creating Biochar from agricultural waste which can be used to increase crop yields and remove carbon from the atmosphere.

Finally, a summary of some key considerations of the evidence base behind introducing circular economy principles for countries, companies and consumers are provided and a list of useful resources is given.

Contents

1. Introduction

The purpose of this report is to review policy interventions which could be used by governments to move their countries toward a more circular economy. It builds on a previous report published by JNCC (Harris 2023), which reviewed a range of policy interventions which could be taken by governments to encourage sustainable consumption, and identified circular economy as one such intervention. It begins by introducing the aims and scope of the report and providing an explanation of what a circular economy is, including a brief review of some of the definitions currently in use. It then reviews the current policy context, both in the UK and internationally. Next, the report introduces examples of circular economy policies currently in use by governments, focussed on a range of sectors, including consumer goods, industry, and agriculture. The examples given include policies aimed both at end consumers and at industry and covers approaches from encouraging behavioural change in consumers through to mandating changes in business practices in law. Finally, the report addresses some potential challenges to introducing circular economy policies.

1.1 Aims and scope of report

The aim of this report is to explain what a circular economy is, and to provide some examples of actions governments could take to implement it.

This report is based on a review of both grey and scientific literature to identify policies and practices that could be implemented by governments to shift to a more circular economy. It includes a review of what a circular economy is, and how this could solve some of the problems caused by our current linear economic model. It then provides examples of circular economy policies which have been implemented by governments in other countries, as well as examples of relevant business practices based on circular economy principles.

1.2 Caveats

This report was written over a short period of time and is not intended to be a comprehensive review of the circular economy concept. Its focus is on government policies and does not provide examples of actions individuals can take themselves. Examples are given to show how circular economy policies could work in practice. The report does not give full details of how these policies could be implemented. Links to useful resources and a full reference list of sources are provided, which give more information on the circular economy concept and the examples given in this report.

1.3 What is a linear economy?

Our current global industrial economy is based on a linear model of resource use and consumption which follows a “take, make, dispose” pattern (Sariatli 2017; MacArthur 2013). Under this model, companies extract resources from the environment which are then turned into products to be sold to end consumers. When these products are no longer functional, wanted, or needed, they are discarded, often into landfill, where the resources or energy the products contain are lost. This model of resource use is based on unsustainable consumption leading to significant losses of finite resources, with both economic and environmental consequences (MacArthur 2013).

Both population and demographic shifts are expected to increase demand for resources in the future. The United Nations predicts that by 2050 the human population will have grown to 9.7 billion people (United Nations 2023). Maintaining current lifestyles for this many people may require the equivalent of three planets’ worth of resources (Esposito *et al.* 2018). Coupled with this challenge, increased demand for resources is also likely to be driven by

demographic shifts. By 2030 three billion people are expected to enter the consuming middle class, leading to increased demand for resources such as oil, coal, and iron ore, in addition to resource intensive goods such as vehicles and electronics (Esposito et al. 2018; MacArthur 2013).

The trend of ever-increasing demand for resources has been occurring for several decades and is accelerating. In 1980, total global extraction of metal ores, fossil fuels, biomass and minerals was 40 billion tonnes (MacArthur 2013). By 2020, this had passed 100 billion tonnes (Circle Economy 2020), and by 2060 it is expected to reach 190 billion tonnes unless urgent action is taken (International Resource Panel (IRP) 2020).

Increased resource extraction to meet this growing demand comes at an environmental cost. Globally, natural resource extraction and processing account for 50% of total greenhouse gas emissions, and 90% of biodiversity loss and water stress (International Resource Panel (IRP) 2020). In 2021, the UK's consumption of resources was estimated to be associated with 30,700 hectares (ha) of deforestation and the predicted loss of 71 species worldwide (GEIC indicator 2023). In addition to these costs, the linear economic model exposes businesses and the economy to significant risk. As demand increases and resources dwindle, the price of raw materials is rising, while increasing competition is preventing companies from passing these costs on to consumers. This is leading to reduced profit for companies and reduced economic output for countries (Sariatli 2017; MacArthur 2013).

1.4 What is a circular economy?

In contrast to the "take, make, dispose" pattern of linear economies, circular economies follow the 4-R Framework in which goods and resources are continually returned to the economy to be Reused, Remanufactured, Recycled or Recovered. In doing so, circular economies design out waste and pollution and keep goods and resources in use for as long as possible, either as products, components, or as raw materials.

Unlike linear economies, which require constant resource extraction to maintain economic growth, circular economies decouple economic growth from the extraction and use of raw materials and inputs. In a well-functioning circular economy, the rate of resource extraction remains well below the rate of consumption, and waste production and pollution remains well below the capacity of the environment to absorb and transform it (United Nations, n.d.). This provides a sustainable economic model with benefits to both people and the environment.

The Ellen MacArthur Foundation has identified three key principles of circular economies:

1. The elimination of waste and pollution
2. The circulation of products and materials
3. The regeneration of nature

For these principles to be realised, the way economies are designed, and function needs to change. For example, a key challenge in creating circular economies is the elimination of pollution and waste, so far as practicably possible. However, there are many products on the market today which have waste built into their design. For example, food packaging such as foil-lined crisp packets cannot be easily recycled and cannot be reused or composted. This does not need to be the case. Products can be designed with a circular economy in mind so that they can be reused, remanufactured, recycled, recovered, or as a last resort composted. In the case of food packaging, biodegradable alternatives to single use plastics have already been developed (Shaikh *et al.* 2021), while some companies have begun to sell products in refillable containers, or without packaging at all (Prelikova *et al.* 2022).

In circular economies, products and materials are kept in use at their highest value for longer, either as functioning products, or when a product is no longer functional, as components or raw materials. This minimises waste and means that materials and products retain their intrinsic value rather than being discarded. This goal can be achieved through product design which maximises the lifetime of goods which serve our needs, and which allows them to be easily repaired when they fail (Circle Economy 2023). An example of this is the Fairphone, a mobile phone built from modular parts which allows users easily to repair their phones by replacing individual components without the need to replace the entire device (Reuter *et al.* 2018).

Biodegradable materials cannot always be reused but these can still be circulated in the economy through composting or anaerobic digestion. In this way, the nutrients the materials contain can be returned to the land where they can be used to grow more food or materials such as timber. Products which can be circulated in this way include food waste, cotton clothing, and wooden products such as furniture.

By moving towards a circular economy, nature is given more space to recover and regenerate. Our food production system provides an example of this. The way we produce food today relies heavily on regular inputs of synthetic fertilisers and pesticides, with negative impacts for both ecosystems and human health. In contrast, food production in a circular economy would shift towards regenerative agricultural practices and closed nutrient loops that reduce the need for fertilisers (Circle Economy 2023). However, the introduction of regenerative agricultural systems must be carefully balanced to ensure that yields are maintained. Achieving this balance and understanding trade-offs compared to land sparing systems is an area of active research. Beyond the food system, circular economies benefit nature by keeping products in use for longer. This reduces the need to extract further finite resources which often comes at an environmental cost, and also frees up more land which can be returned to nature (Ellen MacArthur Foundation, n.d.).

Despite the benefits associated with the implementation of a circular economy, not every commodity can be reused (e.g. whilst food can be composted and used as fertiliser to grow new crops, energy is lost as part of this process and so it is not fully circular). Furthermore, there are also some recognised challenges and potential drawbacks to circular economies. For example, reshaping the economy to make it more circular will create new flows of resources which has the potential to increase waste and emissions if not carefully planned (Korhonen *et al.* 2018). Korhonen *et al.* (2018) state that to avoid this, a global analysis is required to assess the environmental benefits of implementing circular economy strategies.

Some circular economy solutions may cause adverse environmental effects, because additional resources and new infrastructure will be required for their implementation (Vivanco *et al.* 2016). Furthermore, in addition to the potential environmental impacts, the new infrastructure required to transition to a circular economy may come at a significant financial cost which could create a substantial barrier to implementation (Holly *et al.* 2023). A further potential challenge to successfully implementing a circular economy is the possibility of rebound effects, or unintended consequences. This occurs when the increase in efficiency in part of the economy is offset by increased consumption. An example of this is an increase in material usage per product when recycled material is used, so that more waste is generated at the end of the product's life (Castro *et al.* 2022). Another example is that consumers may increase their consumption when products are labeled as sustainable or environmentally friendly, thereby offsetting any benefit from improved production methods or the use of materials with a lower environmental impact (Barkemeyer *et al.* 2023). These potential challenges need to be fully understood and solutions found if circular economy policies are to achieve their intended purpose of reducing waste and environmental impact.

There is currently no agreed upon definition of a circular economy (Kirchherr *et al.* 2017). However, the Ellen MacArthur Foundation has created a useful graphical depiction of a circular economy (MacArthur 2013). It shows how, in a circular economy, products and materials are circulated and reused rather than being discarded (Figure 1).

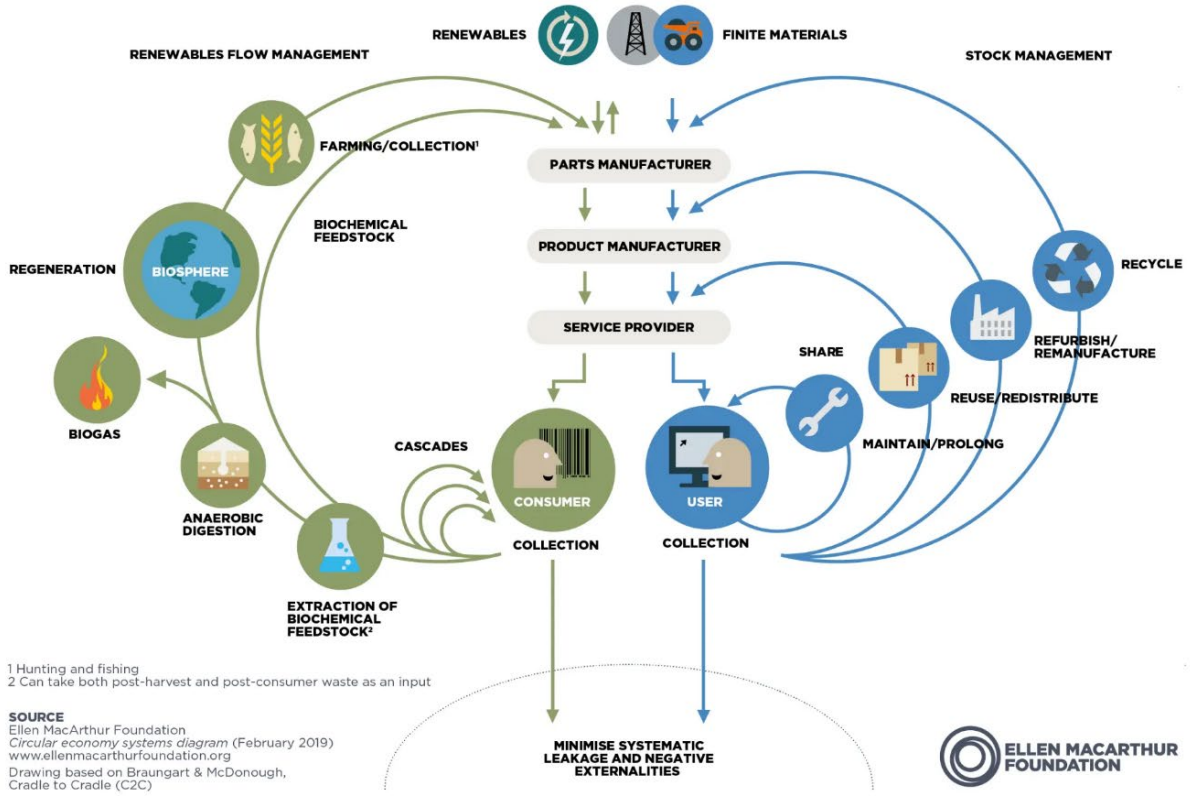

Figure 1. The butterfly diagram developed by the Ellen MacArthur Foundation shows the flow of materials, nutrients, components, and products through a circular economy. The left-hand side shows the biological cycle in which biodegradable materials are broken down, their energy extracted, and their nutrients returned to the earth where they can be used to grow more crops. The right-hand side shows the technical cycle in which products are maintained, reused, refurbished, and recycled, keeping them and their components and materials circulating through the economy. Copyright © Ellen MacArthur Foundation, (,) (Circular economy system diagram, 2019). Reproduced under license. www.ellenmacarthurfoundation.org.

The depiction in Figure 1 aligns well with the definition provided by the United Nations Environment Programme (UNEP 2019), which describes a circular economy as “One of the current sustainable economic models, in which products and materials are designed in such a way that they can be reused, remanufactured recycled or recovered and thus maintained in the economy for as long as possible, along with the resources of which they are made, and the generation of waste, especially hazardous waste, is avoided or minimized, and greenhouse gas emissions are prevented or reduced.” This report uses the UN definition.

1.5 UK and International policy context

The concept of a circular economy is receiving increasing attention from policy makers as a solution to the problems associated with linear economies and is a policy priority for many countries and international organisations.

The United Nations Environment Program has produced a website and resources to support a global transition to a circular economy. The European Union adopted its circular economy action plan in 2020, which sets the agenda for its member states to transition their economies. Circular economy policies have also been made a priority in the United States.

In the United Kingdom, both the government and the devolved administrations have identified moving towards a sustainable and circular economy as a policy goal included in key policy documents:

- Under the Circular Economy Package, the UK has committed "to moving towards a more circular economy which will see us keeping resources in use as long as possible, extracting maximum value from them, minimizing waste and promoting resource efficiency". The UK has transposed this policy package from EU to domestic policy.
- The Environmental Improvement Plan, published in 2023, sets out a series of policy proposals "towards a truly circular and sustainable economy." These include extending producer responsibility for waste and packaging, introducing a deposit return scheme for plastic and metal drinks containers, and banning the supply of some single use plastic items such as plates and cutlery.
- The new Labour Government have identified "a zero-waste economy" as one of Defra's five key priorities, and have announced plans for a Circular Economy Taskforce which "aims to position the UK as an international leader in circular design, technology and industry."
- In 2016, the Scottish Government published Making Things Last: a circular economy strategy for Scotland. This sets out circular economy policies in a number of areas including reuse, repair, remanufacture, and recycling.
- In June 2023, the Scottish Government introduced a Circular Economy bill, which was passed in June 2024 and will require ministers to introduce a range of measures to develop a circular economy in Scotland. This includes publishing a new circular economy strategy.
- In 2021, the Welsh Government published Beyond Recycling: A strategy to make the circular economy in Wales a reality. This sets out how Wales will achieve a circular economy by focussing on six key themes: 1) Driving innovation in materials use, 2) Upscaling prevention and re-use, 3) Building on our recycling record, 4) Investing in infrastructure, 5) Enabling community and business action, and 6) Aligning Government levers.
- In Northern Ireland, the Department for the Economy has published a draft Circular Economy Strategy for Northern Ireland, which sets out a series of proposals for change, including plans to design out waste and support the sharing of goods and materials.

2. Examples of circular economy principles in practice

This section of the report provides illustrative examples of circular economy policies currently in use by governments, across a variety of sectors. This includes deposit return schemes, industrial symbiosis programmes, anti-waste laws and converting waste biomass to biochar.

2.1. Deposit return schemes

Pollution from discarded plastics is a major threat to the environment and a significant challenge for policymakers. Much of this pollution comes from single-use plastic packaging, which enters the environment due to incorrect disposal by consumers, insufficient waste management infrastructure, or unclear waste disposal policies and strategies (Jia *et al.* 2019). Once in the environment, plastic can cause serious problems, including entanglement and ingestion by wildlife, blocking waterways, and leaching of plastic additives into the soil and rivers (Letcher 2020). Furthermore, once in the environment plastics break down over time into microplastics (fragments 5 mm or smaller in size), which can lead to serious environmental and health problems (Bergmann *et al.* 2019).

A significant source of plastic pollution comes from drinks containers. Around 1 million plastic drinks bottles are sold per minute worldwide, with many ending up in the ocean (Rhein & Sträter 2021; Hamade et al. 2020). The environmental pollution this causes, paired with low rates of recycling and reuse, has led to increased interest in the introduction of Deposit Return Schemes (DRSs). Under these schemes, consumers pay a small deposit for each drink purchased, which is then given back when the drinks containers are returned for either recycling or reuse. In many cases, returns are processed using reverse vending machines located in supermarkets and shops, which accept qualifying containers and give a voucher to the value of the deposit, which can be exchanged for cash. DRSs typically include plastic bottles but may also be expanded to include drinks cans and glass bottles and jars. By incentivising consumers to return empty packaging, DRSs aim to significantly increase rates of recycling and reuse and reduce pollution. By keeping drinks containers, or the materials they are made from in circulation, DRSs can play a key role in building a circular economy.

The European Commission included DRSs in the European Strategy for Plastics in a Circular Economy as a mitigation measure against plastic pollution (European Commission 2018). Similarly, several countries are considering or actively planning the introduction of DRSs including Poland, New Zealand, and Ireland. In the United Kingdom, waste policy is largely devolved and responsibility for implementing DRSs falls to each of the four countries. In England, Northern Ireland, Wales and Scotland DRSs are set to be introduced in 2025 for plastic and metal drinks bottles and cans.

In countries where DRSs are already operating, they have been successful at increasing recycling rates. For example, in the European Union, Germany, Denmark, Finland, the Netherlands and Estonia all have DRSs in place, which in 2014 had an average return rate for PET bottles of 94% (European Commission 2018). In Germany, a DRS was introduced in 2003 with the aim of encouraging consumers to choose to buy drinks in multi-use containers, over drinks sold in single-use PET bottles. To achieve this, a deposit of €0.08 is charged on multi-use drinks containers, while a much higher deposit of €0.25 is charged for single use bottles. However, despite the higher deposit on single-use drinks containers, they continue to gain market share over multi-use bottles. In 2018, single-use drinks containers accounted for almost 60% of the market, while the use of multi-use containers has been steadily declining (Rhein & Sträter 2021). A likely reason for this is that consumers value the convenience of PET bottles, and the relatively higher deposit is not enough to disincentivise their purchase.

In a circular economy, priority is given to reuse over recycling. Therefore, while DRSs have been shown to be highly effective at increasing recycling rates, additional policies may be needed to drive a consumer shift towards reusable products.

2.2. Industrial Symbiosis Programmes

In Industrial Symbiosis Programmes (ISPs), manufacturing companies minimise waste and maximise efficiencies by exchanging underused resources, which would otherwise be disposed of. In doing so, these companies maximise the use of resources that would otherwise go to waste, at the same time as generating additional revenue, creating jobs, reducing their environmental impact, and contributing to the circular economy.

ISPs work by forming networks that connect manufacturing companies and help them to identify unused secondary raw materials or waste products, which could be used as raw material in another company. Potential resources are identified by ISP facilitators who are organised into regional teams, with individuals specialised in different industrial sectors. These facilitators visit industrial sites to identify possible opportunities for resources to be exchanged and recycled or reused (International Synergies 2009).

The world's first ISP was the National Industrial Symbiosis Programme (NISP) set up in England in 2005. This programme runs through 12 regional offices across England, with each having a Programme Advisory Group drawn from local businesses. By 2007, NISP had grown to include more than 8500 business from across England, including a wide range of sectors. This enabled the exchange of resources including water, energy and materials. From an environmental perspective, NISP has been very successful. Between 2005 and 2007, it saved 5.4 million tonnes of virgin raw materials, reduced industrial water usage by 2.5 million tonnes, and diverted 1.8 million tonnes of waste from landfill.

In 2013, the Western Cape Industrial Symbiosis Programme (WISP) was launched by the Western Cape Government in South Africa, connecting over 1000 companies. Between 2013 and 2021, WISP diverted more than 143,000 tonnes of waste from landfill, created over 400 jobs, and generated over 8 million USD for the local economy. Some examples of industrial symbiosis in the WISP network include:

- A company which once made pallets from virgin timber changing their business to repairing old pallets, and creating new ones from recycled packaging material.
- A company which uses fabric offcuts from a parasol company to make bags.
- Work under development to use waste sand from moulds used in metal foundries as an ingredient in clay or concrete bricks.

The benefits of ISPs have been widely recognised. NISP has won awards including the Best Carbon Reduction Project at the edie.net Awards for Environmental Excellence, and was highlight by the Worldwide Fund for Nature as one of 20 Worldwide Green Game Changing Innovations. Meanwhile, WISP was a finalist of the World Economic Forum Circulars awards in 2015, and received a gold award in the recycling and waste management category of the 2019 Eco-Logic awards.

In addition to providing benefits to the economy and creating jobs, ISPs have been shown to make a significant contribution to circular economies by ensuring that valuable resources stay in circulation and are not discarded, reducing waste sent to landfill, and reducing carbon emissions.

2.3. Anti-waste laws

Anti-waste legislation can be used to drive a transition to a circular economy. An effective example of this is France's Anti-Waste Law for a Circular Economy (la loi anti-gaspillage pour une économie circulaire) which was passed in 2020. This legislation includes several measures to push businesses and individuals towards more circular practices.

- **Repairability index:** Under the legislation, electronic products such as smartphones, laptops and televisions sold in France must be labelled with a repairability index. This gives products a score between one and ten, based on criteria including the availability of spare parts, the ease with which the product can be disassembled, and the availability of technical documentation. The aim is to help inform customers about the repairability of the product prior to purchase, and to encourage manufacturers to consider repairability during the design stage of new products.
- **A ban on the destruction of unsold goods:** Large companies often destroy their unsold goods leading to significant waste of resources. For example, in the past, €180 million worth of hygiene and beauty products were destroyed annually in France. Furthermore, this practice also causes environmental damage. It has been shown that destroying unsold goods generates 5–20 times more greenhouse gas emissions than reuse would have. Under its Anti-Waste law, France has become the first country in the world to ban this practice. This measure began to be introduced in 2021 and came into full force at the end of 2023, covering all unsold non-food products. Under the law, companies are required to reuse or donate unsold products rather than sending them to landfill or incineration. The aim is that companies will be pushed to better manage their stock and reuse or donate any products that they cannot sell. This measure therefore not only promotes a circular economy for environmental benefits, but also has social benefits.
- **Bans on single-use and unsustainable plastic products:** France's Anti-Waste law includes a ban on all single-use plastics by 2040. To achieve this, lawmakers are required to produce five-year plans up to 2040 which provide for the phasing out of all single use plastics. Furthermore, the law also provides for the fast-track ban of some single-use plastic products which are particularly problematic. This includes expanded polystyrene boxes, plastic teabags, plastic confetti, and plastic plates, containers, and cutlery in fast-food restaurants. The law also includes measures to encourage zero-waste practices which eliminate the need for plastics, such as an obligation for dine-in restaurants, including fast-food chains, to provide customers with reusable plates and cutlery, and an obligation for public institutions to provide water fountains.

Although France's Anti-Waste law is one of the most ambitious laws of its type, other countries have enacted legislation or have policies with similar aims. For example, although it does not go as far as France, the member states of the European Union have agreed that the destruction of unsold textiles will be banned. In the United Kingdom, measures have been implemented to limit the waste and environmental impact of single-use plastics. For example, mandatory charges for plastic carrier bags have been introduced in all four countries of the UK, leading to a 98% reduction in their use. More recently, from 2023, England has introduced a ban on some single-use plastics including cutlery, plates, and polystyrene containers. This follows a similar ban on some single-use plastics enacted by the European Union.

2.4. Converting waste biomass into biochar

Agriculture has been identified as a significant cause of environmental stressors such as soil degradation, and nutrient leaching (Skinner *et al.* 1997). Furthermore, agriculture has been identified as the cause of almost 90% of deforestation worldwide (FAO 2022), and is a major source of both nitrous oxide and methane, which are potent greenhouse gases (Defra 2023). Agricultural production methods often produce a significant amount of waste biomass such as leaves, straw, and husks from crop plants, and wood chips and branches left over from timber production. These waste products are often left to decompose, where the energy they contain is lost, and the carbon they contain is released into the atmosphere.

In a circular economy these waste materials would be upcycled to benefit both people and the environment. One way in which this can be done is by converting waste biomass into biochar. Biochar is produced through a process called pyrolysis in which biomass is heated in a low oxygen environment to temperatures up to 1000°C (Rollinson 2016). In these conditions, it is converted into a stable form of carbon, which does not easily break down and cannot easily escape into the atmosphere, meaning it can potentially be stored in soils for hundreds or even thousands of years. This property of biochar means that it can contribute to reducing net greenhouse gas emissions, as carbon absorbed from the atmosphere during a plant's growth is locked away for a long period. An example of this is the "Reverse Coal" project, being run on the Lapwing Estate near Doncaster, and supported in part through advice provided by the UK government. In this habitat restoration project, short rotation willow coppice (SRWC) is grown on re-wetted peatland, where it absorbs CO_2 from the air through photosynthesis. It is then turned into biochar and buried, removing carbon from the atmosphere for the long term. Government support for projects such as this have the potential to play a role in national efforts to tackle climate change. If waste products from crops or other sources were used to create biochar, rather than growing plants for this specific purpose, this could contribute to both a circular economy and climate change mitigation efforts.

In addition to locking in carbon, biochar has applications that can directly benefit the environment. This includes being used as filter in wastewater treatment, and as an ingredient used to speed up the anaerobic digestion of organic waste (Singh *et al.* 2022). However, one of its potential biggest uses is in agriculture, where it can be added to soils to increase their water holding capacity, reducing the risk that crop plants are impacted by droughts. Furthermore, biochar can act as a liming agent, raising the pH of soils, which increases their capacity to adsorb and retain nutrients needed for plant growth (Singh *et al.* 2022). Biochar can also act as a carrier of nutrients and can improve microbial activity in soils. In a test, radishes grown on biochar supplemented soils had an up to 95% increase in dry matter content compared to a control group (Chan et al. 2008). This suggests biochar has the potential to convert agricultural waste into a product that can itself increase the fertility and productivity of soils and boost agricultural production. Thus, biochar can create a closed resource loop and provides a clear example of the circular economy concept.

3. Policy interventions

The examples given in this report illustrate different actions governments can take to implement circular economy principles in their countries. Broadly, these actions fall into four categories:

- Policies which incentivise or nudge consumers to change their behaviour (e.g. section 2.1.).
- Government establishment and facilitation of circular economy programmes in industry (e.g. section 2.2.).
- Legislation requiring businesses to adopt circular economy principles (e.g. section 2.3.).
- Government support and advice for trial schemes aiming to implement a circular economy (e.g. section 2.4.).

These examples do not provide an exhaustive list of the policy interventions which are possible, but instead are intended to provide examples of the broad range of actions which governments could take. For further examples see the documents listed under Section 6 (Useful resources).

3.1. Effects on countries from transitioning to a circular economy

The concept of a circular economy has been gaining traction with policymakers as demonstrated by the circular economy strategies and policies published by UK and international governments. Circular economies have the potential to provide many benefits to countries which implement them. For example:

- Circular economies produce less waste and lower greenhouse gas emissions and so can help countries meet their environmental and climate commitments.
- In circular economies, economic growth (as measured by GDP) may be boosted through the emergence of new circular activities, and more efficient and productive use of resources (e.g. see section 2.2.).
- Studies have shown that implementing a circular economy is likely to lead to job creation with benefits for the economy and people (e.g., Horbach, Rennings & Sommerfeld, 2015).

However, in addition to these benefits, there are challenges and drawbacks associated with circular economy policies, which need to be addressed. For example:

- The implementation of some circular economy principals will require the restructuring of material flows, which has the potential to increase waste and emissions (Korhonen *et al.* 2018).
- Some circular economy principles will require new infrastructure to implement, which may come at a significant cost (Holly *et al.* 2023).
- In a circular economy, consumers may feel free to increase their consumption due to the perceived lower environmental impact of consumer goods. This may create a rebound effect, where any benefits from increased efficiency of production and more sustainable products are offset by increased consumption (Castro *et al.* 2022).

3.2. Effects on companies and consumers from transitioning to a circular economy

Reduced demand for raw materials in circular economies has the potential to lead to significant cost savings for businesses, which may lead to lower prices for consumers. In a circular economy, new business opportunities would emerge, such as collection and "reverse-logistics" companies needed to facilitate Deposit Return Schemes. Products in a circular economy are designed to be long lasting, reducing the rate at which they become obsolete, and lowering replacement costs for consumers.

4. Conclusions

The “take, make, dispose” linear economic model in use in much of the world is unsustainable, both economically and environmentally. This report introduces, with examples, the concept of a circular economy, which aims to address these problems. Circular economy principles are broad and can be applied to all sectors of an economy, from food packaging (sections 2.1 and 2.3) to industry (section 2.2) and agriculture (section 2.4). Introducing circular economy principles can bring economic benefits. For example, when well implemented, circular economy policies have the potential to create both jobs and economic growth (Horbach *et al.* 2015) and may also lead to significant material cost savings (Ellen MacArthur Foundation, n.d.). Furthermore, circular economy principles can bring substantial environmental benefits. By improving efficiency and reducing waste circular economies have a lower environmental impact and produce lower greenhouse gas emissions. In addition to benefitting countries, circular economy policies can also benefit consumers by increasing the lifespan of consumer goods and reducing costs (Ellen MacArthur Foundation, n.d.).

Despite these benefits, the implementation of circular economy policies does present challenges which must be overcome. These include high costs of introducing new infrastructure such as reverse vending machines (section 2.1), and the potential for rebound effects in which circular economy policies cause unintended consequences (Castro *et al.* 2022).

The examples presented in this report demonstrate that circular economy principles can work in practice and can bring significant benefits. However, for circular economy principals to be implemented across all sectors of the economy, further research is needed to ensure that any potential negative impacts are identified and mitigated.

5. Unanswered questions and next steps

This report has provided examples of circular economy principles in practice in a number of difference sectors of the economy. However, these examples have all been implemented within one country and mostly at relatively small scales. However, in our globalised world trade crosses borders, with resource extraction, manufacturing, consumption, and waste disposal often taking place in different countries or even continents. The interconnectedness of our world means that for circular economy principles to be implemented on a large-scale, international agreements are likely to be necessary. Further work is now needed to find ways to introduce circularity to complex cross border supply chains.

This report also highlighted areas of the economy where introducing a circular economy has been possible. However, there are parts of the economy where it may be very difficult to effectively implement circular economy principles. For example, the aviation industry was responsible for 920 million tons of CO_2 emissions in 2019 (Markatos & Pantelakis 2022) and the number of flights taken each year globally is likely to continue to increase if current trends continue. However, for aviation there is currently no mainstream viable alternative to using fossil fuels as an energy source and this will make it difficult to fit the aviation industry into a circular economic model. Further work is therefore needed to identify how aviation and other energy intensive industries can fit into a future world in which economies are circular.

Future work could also focus on developing a framework for evaluating sustainability policy interventions, circular economy included, which identifies trade-offs and addresses impacts and gains.

6. Useful resources

6.1. Guides and technical reports

Towards the circular economy Vol. 1: an economic and business rationale for an accelerated transition: https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an

Towards the circular economy Vol. 2: opportunities for the consumer goods sector: https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-vol-2-opportunities-for-the-consumer-goods

Towards the circular economy Vol. 3: accelerating the scale-up across global supply chains: https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-vol-3-accelerating-the-scale-up-across-global

The Circularity Gap Reports: https://www.circularity-gap.world/

6.2. Policy documents

The UK Government's Environmental Improvement Plan: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1168372/environmental-improvement-plan-2023.pdf

Making Things Last: a circular economy strategy for Scotland: https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2016/02/making-things-last-circular-economy-strategy-scotland/documents/00494471-pdf/00494471-pdf/govscot%3Adocument/00494471.pdf

Beyond Recycling: A strategy to make the circular economy in Wales a reality: https://www.gov.wales/sites/default/files/publications/2021-03/beyond-recycling-strategy-document.pdf

A draft Circular Economy Strategy for Northern Ireland: https://www.economy-ni.gov.uk/sites/default/files/consultations/economy/draft-circular-economy-strategy-for-northern-ireland-main-report.pdf

EU Circular Economy Action Plan: https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF

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