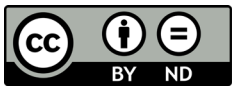
Daisy Silvennoinen & Marja-Liisa Ruotsalainen

Towards a circular bioeconomy

A comparative analysis of Finland, Norway, Ireland and Scotland

Publication series: Karelia University of Applied Sciences Publications C: Reports, 97

Authors: Daisy Silvennoinen, Karelia University of Applied Sciences
Marja-Liisa Ruotsalainen, Karelia University of Applied Sciences



ISBN 978-952-275-371-7
ISSN 2323-6914

Karelia University of Applied Sciences 2022

NPA project "GOALs" (Suitable Sustainability Goals for SMEs) is funded by the Northern Periphery and Arctic Programme of the European Union

Contents

Foreword

Finland is a country of small businesses, and in sparsely populated areas it is necessary to consider impacts of operations and adapt actions to changing environment. Small and medium-sized companies have goals and work towards sustainable business models. In the development work with companies, it has been recognized that in the rush of everyday life, SMEs may have challenges setting clear, measurable metrics for these goals. Many industries and products have industry-specific quality marks, certificates, etc., but little is said about them in the company's strategic management and customer communication.

At Karelia University of Applied Sciences, we want to support and promote the vitality of companies, because as an educational organization we train experts for work. As a development measure, we implemented the international research, networking and preparation project GOALS - Suitable Sustainability Goals for SMEs with funding from the Northern Periphery and Arctic program. In this six-month project, which took place in Spring 2022, extensive investigative work has been done by collecting material using different methods and analyzing them, as well as implementing the dissemination of expertise.

This publication is one of the research reports of the project. It focuses on the sustainable development actions of the participating international partner countries, and presents the legislative boundary conditions, regulations and guidelines of the circular economy in the bioeconomy sector. Here, the guidelines for sustainable development of the bioeconomy sector in the circular economy are examined, especially from the marine & fisheries, forest, and agriculture segments. These industries were chosen based on the needs of international partners committed to the preparatory work from Finland, Norway, Ireland and Scotland. The report defines the circular bioeconomy in the NPA program, takes regional strategies into account and highlights examples of good practices that can be emulated. The report was made by Daisy Silvennoinen, an expert in environmental policy and business development, who works at the Karelia University of Applied Sciences in project assignments.

By publishing this report, we want to make a large amount of information available to others as well.

In Joensuu 26.10.2022

Marja-Liisa Ruotsalainen
Senior RDI Specialist, project manager at GOALS-project
Karelia University of Applied Sciences

1 Circular Economy and natural resources of the NPA

The annual extraction of natural resources has tripled since 1970.[1] In correlation with this, greenhouse gas emissions are rising, and large parts of the world are facing considerable waste and pollution issues.[2] The rate and ways of natural resources exploitation (e.g. agriculture, marine and fisheries) has presented the need for more sustainable and efficient use of resources. For example, forests are the largest land-based natural resource in Europe with increasing demands to use this resource for many different purposes.[3] Biomass and land area are already scarce resources complicating the need to feed and produce raw materials for products, while reducing greenhouse gas emissions at the same time.[4] Residue and waste (e.g., food, fishing gear, packaging materials, etc.) are also problematic waste fractions impacting on biodiversity and climate. For example, the amount of materials used for packaging is continuously growing and in 2017, packaging waste in Europe reached a record 173 kg per inhabitant, highest level ever recorded.[5] Consumption of plastics is also expected to double in the next 20 years.[6] Half of total greenhouse gas emissions and more than 90 percent of biodiversity loss and water stress come from resource extraction and processing.[7]

The essence of the circular economy is the idea of moving away from the linearity that has dominated value chains for more than 200 years, breaking with the 'take-make-waste' tradition.[8] This means transitioning towards a circular approach under which we refrain from material extraction and optimize the use of existing materials by minimizing and eliminating waste throughout the value chains.[9] Circular principles seek to recover and preserve the embedded value in materials, components, and products.[10] The

[1] Deloitte 2020.
[2] Ibid.
[3] Wolfslehner et. al 2020.
[4] Deloitte 2020.
[5] EC 2020. p.11.
[6] EC 2020. p..12.
[7] EU Newsroom 2020.
[8] Circular Norway 2020.
[9] Ibid.
[10] CIRCULÉIRE 2022.

current economy is stated as still mostly linear, with only 12 percent of secondary materials and resources brought back into the economy, as many products break down too easily, cannot be reused, repaired, or recycled, or are made for single use only.[11] To enable Europe, most importantly EU and European Trade Area achieve the UN's Sustainable Development Goals and the various countries' climate targets, the transition to a circular economy is deemed urgent. Transitioning to a resource-efficient circular economy has been on the forefront of the EU's policy framework. This transition to so called "circularity" or "circular economy" requires actively sought improvements in the way products are designed, produced and consumed.[12]

The EU has been a strong driver of the transition to a more circular economy since it published its first action plan in 2015.[13] The second EU action plan, published in 2020, is regarded as one of the main building blocks of the European Green Deal, which aims to achieve climate neutrality by 2050 and transform the EU into a society where economic growth is decoupled from resource use.[14] The EU Circular Economy Action Plan is the most recent. It is a more ambitious approach to using the resources, involving groundbreaking legislative initiatives for sustainable production and consumption in waste, and continued high standards for a toxic-free environment where entire life cycle of products need to ensure resources are kept in the EU economy for as long as possible.[15] The plan emphasizes the importance of 'getting the economics right', so that economic structures and drafted incentives steer developments in the right direction.[16] This Involves (i) acting at community level by e.g., ecolabelling of financial products, (ii) the discussion of non-financial disclosure in the Commission action plan on financing sustainable growth, and (iii) strongly urging individual member states to make greater use of economic instruments designed to promote the circular economy.[17]

The Member States discussed the EU Circular Economy Action and its proposals for legislation and sustainable product policy in end of March 2022.[18] The European

[11] EC 2020.
[12] Suikkanen, J., Nissinen, A 2017.
[13] Regjeringen 2022.
[14] Ibid.
[15] Regjeringen 2022.
[16] EC 2020.
[17] Ibid.
[18] eur-lex.europa, Document 52020DC0098: COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS, COM/2020/98 final.

Commission adopted the proposed package of measures 30.1.2022.[19] The most important initiative under the action plan is the development of a more coherent product policy framework, which include **legislative initiatives to enhance circularity in product design,** driven by reformulation of the Ecodesign Directive and expansion of its scope to cover a wider range of products and their characteristics.[20]

According to Regjeringen 2022, the regulatory measures and other initiatives are for seven important sectors termed by the EU as **"key product value chains".** These are electronics and ICT; batteries and vehicles; **packaging; plastics; textiles; construction and buildings; and food, water and nutrients.** The EU waste policy is also being developed in order to retain waste in material cycles and extract more of the value from waste within Europe's borders. The aim is that this will give a wider role for the recycling industry to supply materials for new production and guarantee that resources are retained in circulation as long as possible. On one hand, the EU is implementing legislative initiatives to drive **circularity in production cycles,** including strengthening the regulatory framework for chemicals, with the aim of creating a toxic-free environment as set out in the European Green Deal. On the other hand, EU's **initiatives to strengthen consumer rights** and to **introduce mandatory green public procurement requirements** are hoped to play an important role in creating awareness and strengthening the demand side of material cycles. The aim is to ensure that the quantities of waste-based raw materials and secondary raw materials in circulation in the economy can be increased sustainably and without causing any additional environmental damage.[21]

More recently, in the Circular Economy Action Plan (CEAP 2.0), the European Commission highlighted that implementation of circular economy principles will increase the EU's GDP by an additional 0.5 percent by 2030 while creating 700,000 new jobs.[22]

[19]EC 2020.
[20] EC 2022.
[21]Regjeringen 2022.
[22] CIRCULÉIRE 2022.

1.1 Natural resources circularity

1.1.1 CE implications for Agriculture and Forest resources across NPA region

Farmers and forest natural products (i.e., extract, collect from forests, not logging), and related industries producers face two, seemingly contradictory challenges: the need to feed and produce raw materials for products for millions of people, and reduce greenhouse gas emissions at the same time.[23] On one hand, biomass and land area are already scarce resources and will be in increasing demand in a circular zero-emission economy, as carbon from renewable sources such as trees are good replacement for fossil resources, both for fuel and as raw material in the production of various products.[24] On the other hand, the production of biomass must take place within the framework of sustainable use of land area; meaning considerations need to be taken for biodiversity, food production and carbon storage.[25] The use and processing of natural resources and the manufacture of products have environmental impacts e.g., on greenhouse gas emissions.[26] In order to ensure this, the use of land area and biomass needs reconsidering and prioritising, meaning a shift to circular economy is inevitable.[27]

Agricultural practices can result in a loss of nutrients, significant emissions and the use of chemical fertilisers based on fossil fuels.[28] Slurry is rich in nutrients and has valuable fertilisation properties that are worth utilising. However, with present practices nutrients are usually lost and end up as pollution to air, water and other ecosystems.[29] Organic waste also emits greenhouse gases, such as methane and nitrous oxide, turning the resource into a problem in itself. This affects the environment, while similarly representing economic loss for farmers.[30] Maintaining yield also creates a need for chemical fertiliser, another source of greenhouse gas emission, leaving farmers and the agri-food industry seeking solutions that can increase both their sustainability and profitability.[31]

---

[23] Theexplorer 2022.
[24] Deloitte 2020.
[25] Ibid.
[26] Sitra 2022.
[27] The Ministry of Agriculture and Forestry 2022.
[28] Rosemarin et. al 2020. Theexplorer 2022.
[29] Theexplorer 2022.
[30] Ibid.
[31] Ibid.

Organic production (both primary production and forest wild collection), as an example, do play a dual societal role, where, on one hand, they provides for a specific market responding to consumer demand for organic products and, on the other hand, it delivers publicly available goods that contribute to the protection of the environment and animal welfare.[32]

In forest sector, circular economy is defined by resource efficiency, closed loops and collaboration, with bioeconomy usually seen as a response to climate challenge by bio-based, renewable material.[33] In February-March 2018, the European Commission published a Roadmap for the Communication updating the 2012 European Bioeconomy Strategy.[34] The Strategy aim to pave "the way to a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of renewable resources for industrial purposes, while ensuring environmental protection".[35] In the strategy, the bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles.[36] This includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forest wild collection, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services.[37]

[32] FORI 2021.
[33] Näyhä A 2019.
[34] EC 2018.
[35] Ibid. p.8.
[36] Ibid. p.4.
[37] EC 2018. p.4.

Figure 1. Five objectives of circularity for Europe's bioeconomy. Reducing dependence on non-renewable, unsustainable resources means whether sourced domestically or from abroad.[38]

A sustainable European bioeconomy is considered to support the modernisation and strengthening of the EU industrial base through the creation of new value chains and greener, more cost-effective industrial processes.[39] It is considered a renewable segment of the circular economy that can turn bio-waste, residues and discards into valuable resources, and can create the innovations and incentives to help retailers and consumers cut food waste up to 50 percent by 2030.[40]

The Commission aims at ensuring the sustainability of renewable bio-based materials, including through actions following the Bioeconomy Strategy and Action Plan.[41] This will be ensured by the EC actively supporting and promoting all types of innovations and practices for sustainable food and farming systems, forest wild collection and bio-based production. Examples of key aspects mentioned in the strategy are:

[38] EC 2018. p.8-10.
[39] EC 2018. p.6.
[40] EC 2018. p.6.
[41] EC 2018b.

- livestock sector innovations increasingly allow to safely turn certain food waste into feed for animals, provided the applicable rules and legal requirements are observed. The innovations would save land currently used to feed animals for use in food for humans.[42]
- better recycling of high value organic residue streams could translate into very significant economic (additional income added value, jobs) and environmental gains (save carbon dioxide).
- circularity will contribute to restoring ecosystems, for instance achieving plastic-free seas and oceans.

The European Environmental Agency also already advises that bio-based, biodegradable materials alternative to plastics should be emphasized where the risk of dispersion into the ecosystem is high, such as lubricants, materials subject to wear and tear, and disposable products.[43] Undertaking the necessary actions are considered to further contribute to the Sustainable Development Goals target of achieving land degradation neutrality by 2030.[44]

1.1.2 CE implications for Aquaculture and fisheries resources

The geographical position of the Northern Periphery and Arctic places it at crossroads in the light of Climate Change and biodiversity discussion and ongoing circularity regulatory frameworks being implemented across the EU. Due to a geography and climate largely unsuited for land-based food production, and with no or limited access to arable land due to glacial ice and barren rocks, many coastal communities and countries in the Northern Periphery and Arctic areas traditionally live from the sea.[45] On the other hand, since arable land and fresh water are restricted resources in many Arctic regions, increased demand for food security is considered of utmost importance. Additionally, with a climate largely unsuited for land-based food production as a result of geographical location, effects from climate changes mainly driven by anthropogenic CO2

[42] EC 2018b., Guidelines for the feed use of food no longer intended for human consumption (2018/C 133/02).
[43] EC 2018.
[44] Ibid.
[45] Bellona 2015. p.94.

emissions, are especially evident in the region, resulting in losses of biodiversity and unpredictable changes in availability of important marine food species.[46]

Research show that 35 per cent of the fish harvest is either lost or wasted globally; some of this waste is dumped back into the ocean, potentially causing environmental damage to marine ecosystems, while others dispose these in municipal waste systems, putting pressure on landfills.[47] Oceans are stated to absorb more than 20 million tons of CO2 each day, leading to acidification.[48] Aquaculture and fisheries also generate leftover residues and waste such as fish trimmings (guts, heads, tails, frames, and skin), bycatch, aquaculture mortalities, shells and various leftover biomass.[49] Annual discard from the world fisheries has been estimated to stand at approximately 25 percent of the total catch.[50] This residual biomass can be divided into three categories: (a) coproducts which contribute to the profit of the business; (b) by-products that do not generate substantial income but are cash-neutral when accounted for disposal costs; and (c) waste which costs business money to dispose of.[51] Fish waste can for example be minced and sold as fish meal, used in animal feed.[52] Fish skin is an example of byproduct from the fishing and fish farming industry. After the fish has been harvested it is filleted, skinned and cut into portions for the retail and catering markets in Europe and around the world, the skins most often end up as waste.

The fishing industry therefore generates a huge percentage of fish residuals that go unused, and when fish producers underutilise these residuals, they lose out on potential revenue and incur costs for waste transport and storage.[53] Some companies have been forerunners in utilizing of by-products. For example, Nordic Fish Leather and its predecessors have for over 20 years worked on solutions to turn this neglected high-quality raw material into valuable product.[54] The results can today be seen in outstanding products made by both individuals and large designer companies. Still, a lot

[46] Bellona 2015. p.93.
[47] Theexplorer 2022b.
[48] Oneplanetnetwork 2017.
[49] Rudovica et. al 2021.
[50] Arason
[51] Rudovica et. al 2021., Zero Waste Scotland 2015.
[52] Rudovica et. al 2021.
[53] Theexplorer 2022b.
[54] Theexplorer 2022b.

of potential is left unused, and the EU action plan aims to speed up innovations within and across these value chains.

The state of Aquaculture and fisheries via NPA regional examples

In Ireland, approximately 40 per cent of the population lives within 5 kilometres of the Irish coast, meaning Ireland's coastal and marine areas provide it with vital environmental, recreational, cultural and economic goods and services.[55] The environmental status assessment for Ireland by EPA (488,762 km2) showed that the country's nearshore coastal and offshore marine waters are predominantly clean, healthy and biologically diverse.[56] However, based on the findings, additional measures were stated as required to protect the valuable ecosystems and species.[57] The marine areas are stated as impacted by many human induced pressures, including fishing, climate change, eutrophication, litter, noise and other forms of pollution.[58] The key problems mentioned in the Ireland report regard for example **overfishing and marine litter.** Plastic waste is a major waste fraction in Ireland. It is estimated that 8 million tonnes of plastic enter the oceans each year.[59] This is particularly pertinent to Ireland, with a marine territory 10 times the size of its land area. Mircoplastics have been documented in over 90 per cent of Ireland's protected marine environments in the first major study aimed at understanding the true extent of pollution around the entire coast.[60] Of 87 Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), 79 were found to have the man-made materials buried in sediments, the vast majority coming from clothing and **fishing equipment**.[61]

Scotland has also been a major actor in aquaculture and fisheries. **Fish waste** is still considered a problem with Scotland-wide fish processing waste estimated at 160,000 tons.[62] In Scotland, some fish are immediately frozen upon arrival and exported as a whole, so the processing occurs elsewhere. Still, most fish are stated as processed locally, which generates a significant amount of waste. During processing, some

[55] EPA 2020.
[56] EPA 2020. p.193.
[57] EPA 2020. p.193.
[58] EPA 2020. p.200.
[59] EC 2018c.
[60] The Irish Times 2021.
[61] Ibid 2021. EC 2018c.
[62] Rudovica et. al 2021.

trimmings (guts, heads, tails, frames, and skin) are removed.[63] Research findings show that there exists a potential of well-established international markets for various fish parts from Scotland to West Africa and East Asia for example, even though it is currently not cost-effective to transport fish waste long distances.[64] Still, some Scottish fish waste is exported shorter distances and processed into higher-value products (e.g., fish by-products processed in Norway).[65] Currently, about 15 percent of fish feed is recycled into fish meal, and fish feed in Scotland remains more expensive (up to 40 percent in 2014) than in other countries such as Norway.[66] Plastics and marine litter is also considered a challenge with better **recycling of fishing equipment** included in the Marine Litter Strategy.[67] Since 1 January 2014, the Waste (Scotland) Regulations have been in force, with all organisations operating in Scotland, big and small, required to **recycle their plastic**, metal, glass, paper and card or risk a fine (food waste is also considered to some extent).[68]

In Norway (based on Rudovica et. al 2021), salmon farming is among the most successful aquaculture industries, a production growth that is substantially higher than aggregate aquaculture production with key facets for this development from innovations and productivity growth. Norway is currently the largest producer of Atlantic salmon, yielding 93 percent of total Norwegian aquaculture production. In the report, Norway's aquaculture sector has strict rules for processing and handling waste in production, and in principle, all biological material is processed; the only fraction that is not being economically exploited is the blood from the slaughter process, for which there is still no usable technology. Most of the residual raw material from fish and shellfish is currently used, making an important contribution to value creation in the fisheries and aquaculture industry. In open sea cages however, **no technology for sludge collection currently exists**, and unless resource-efficient solutions like integrated multi-trophic aquaculture (IMTA) are applied, valuable resources are lost.[69]

---

[63] Pitcairn et al., 2017., Rudovica et. al 2021.
[64] Rudovica et. al 2021.
[65] Zero Waste Scotland 2015., Rudovica et. al 2021.
[66]Rudovica et. al 2021., Zero Waste Scotland 2015.
[67] Scottish Government 2021.
[68]Ellen MacArthur Foundation 2022.
[69]Rudovica et. al 2021. The report gives a summary of marine waste utilization in Norway (opportunities and challenges of three specific sectors of marine waste; fish, shellfish, and seaweed waste) are presented in the report. The residual raw materials are defined as the non-primary products obtained from marine raw materials, which are fish and shellfish (crustaceans and molluscs), and seaweeds farmed and caught under Norwegian quotas in Norwegian waters.

In 2019, Norway alone generated some 964 000 metric tons of residual raw materials from seafood, utilizing over 84 per cent of these raw materials.[70] However, only 15 percent went to human consumption, even though development of high-added-value products from these side streams has been given priority in recent years as a result of detection of a broad range of biopolymers, multiple nutrients and functional compounds that could find applications for human consumption or use in livestock/pet food, pharmaceutical and other industries.[71] In 2020, about 861,000 tons (85 percent) of the residual raw material was utilized to produce various products.[72]

The Farm to Fork Strategy

The Farm to Fork Strategy is also mentioned in the EU Action Plan. It is at the heart of the European Green Deal aiming to make food systems fair, healthy and environmentally-friendly.[73] The strategy sets out both regulatory and non-regulatory initiatives, with the common agricultural and fisheries policies as key tools to support a just transition.[74] The aim is to comprehensively address the food value chain.[75] Food companies, from local retailers to large corporations, also have incentives to reduce agricultural emissions as a response to consumer and shareholder demands.[76]

[70] Theexplorer 2022b.
[71] Rudovica et. al 2021., Theexplorer 2022b.
[72] Myhre et. al 2021 in Rudovica et. al 2021.
[73] EC 2020b.
[74] EC 2020b.
[75] EC 2020. p.14.
[76] Theexplorer 2022.

Food security -local value creation- decoupling economic growth from CO2 emissions

Figure 2. EU Farm to Fork strategy[77]

Packaging and re-use

In addition to the EU Farm to Fork strategy, the Commission will also consider specific measures to increase the sustainability of food distribution and consumption. Under the sustainable products initiative, legislative initiative on reuse to substitute single-use packaging, tableware and cutlery by reusable products in food services will be enacted.[78] Actions aiming at water reuse and efficiency and nutrient recovery will also be considered.[79]

1.2. Summary

Across all three coastal cases for marine and fisheries, **food waste and marine litter** are considered waste fractions that need addressing, even though the level and scale of actions defined differ per country. The problem with marine and fisheries side streams

[77] EC 2020b.
[78] EC 2020. p.15.
[79] EC 2020. p.15.

are also given high priority across all regions with these termed as "waste" to be handled throughout business value chains. In agriculture and forest resources use, resource efficiency and food security are highlighted tracing from the need for **securing biodiversity, food production and enhancing carbon storage.** These align with the EU framework where circularity in extraction and processing of natural resources are the main focus areas for the European Commission's (EC's) Circular Economy Action Plan. In the EC's Circular Economy Action Plan, one way of ensuring circularity in natural resource use and biodiversity conservation (agriculture, forest, aquaculture and fisheries) is through regulations and policy actions that drive circularity. In the plan, the Commission will:

- review Directive 94/62/EC27[80] to **reinforce the mandatory essential requirements for packaging to be allowed on the EU market** in addition to other measures in order to ensure that all packaging on the EU market is **reusable or recyclable** in an economically viable way by 2030.[81]
- propose **mandatory requirements for recycled content and waste reduction** measures for key products such as **packaging and construction materials** in order to increase uptake of recycled plastics and contribute to the more sustainable use of plastics.[82]
- ensure the timely implementation of the **new Directive on Single Use Plastic Products and fishing gear** to address the problem of **marine plastic pollution**.[83]
- **rules on measuring recycled content in products** will be developed for the first time.[84]
- enable Member States to use **value added tax (VAT) rates to promote circular economy** activities.[85]
- enhance **disclosure of environmental data by companies** in the upcoming review of the **non-financial reporting directive.**[86]
- support a business led initiative to **develop environmental accounting principles** that **complement financial data**.[87]

---

[80] European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste, OJ L 365 31.12.1994, p. 10.
[81] EC 2020. p.12.
[82] EC 2020. p.12.
[83] EC 2020. p.13.
[84] EC 2020. p.13.
[85] EC 2020. p. 20-21.
[86] EC 2020. p. 20-21.
[87] EC 2020. p. .20-21.

The implemented regulatory measures and other initiatives have been prioritized for the seven important sectors termed “key product value chains. Five out of the seven product value chains directly impact marine and fisheries, and forest and agriculture raw material extraction, and processing sectors.

2 CE Action Plan as reflected in regional strategies across the NPA-region

This chapter looks at national legislation and policy measures are framed to support the Circular Economy Action Plan. The areas included in this report are Finland, Ireland, Norway and Scotland.

2.1 Finland

In Finland, CE is defined as an economy where materials are utilized efficiently and sustainably, and they remain in circulation for a long time and safely. Products are also shared, leased, repaired and recycled. Servicification is part of the circular economy, for example, when services replace the ownership of products by paying for use or result. The circular economy is a new operating method for the economy that produces economic well-being within the limits of the planet's carrying capacity. It utilizes digitalisation efficiently and will renew the structures and operating models of society. The circular economy is a means for reducing the use of natural resources.[88] Circular economy solutions are considered needed to safeguard biodiversity and solve the climate crisis. The strategy "calls" businesses to join forces in creating a fair transition to a society in which the country maintains the value of what it produces through smarter design and shifting from owning products to using services.[89]

Finland has prepared a strategic programme to promote a circular economy. This is summarized under the Ministry of the Environment website.[90] According to the website, the aim is to transform the economy into one that is based on the principles of circular economy by 2035. With the programme, the Finnish Government wants to strengthen Finland's role as a leader in the circular economy. The transition into a circular economy is also considered a step towards achieving the Government's carbon neutrality

[88] Ministry of the Environment 2022.
[89] Sitra 2022b.
[90] Ministry of the Environment 2022.

target by 2035. The Finnish Government adopted the resolution on promoting a circular economy on 8 April 2021. The following documents relate to the adoption:

- Government resolution on the Strategic Programme for Circular Economy 8.4.2021;
- Press release of Ministry of the Environment 8 April 2021: Finland's Circular Economy Programme sets targets to curb overconsumption of natural resources.

The strategic programme to promote a circular economy sets out objectives for the use of natural resources. It sets the objectives and indicators, specify the measures to be taken and allocates the resources needed to promote the circular economy and achieve systemic change.

A broad spectrum of stakeholders such as different ministries and research institutes, in dialogue with companies, business sectors and local governments, are stated to have participated in the process of preparing the resolution. The preparation of the programme for circular economy is stated to have also been supported by a citizens' jury, consisting 50 citizens randomly selected from among volunteers. In addition, all citizens are stated to have been given an opportunity to participate in the preparation of the programme through an online brainstorming platform.

Different strategies have been created to steer Finnish economy towards circularity. For example, the strategy -Finnish road map to a circular economy 2016-2025. A myriad of Circular economy incentives have also been put in place, for example:

- Finland's sustainable growth programme has reserved EUR 110 million euros for Business Finland to finance circular economy solutions and demonstration plants for industry.[91]
- The EU regional and structural policy programme Innovation and Skills in Finland 2021-2027, aims to promote energy efficiency and the circular economy while reducing greenhouse gas emissions.[92] Funding will also be directed to measures taken to prepare for climate change. Organisation responsible is the Ministry of Economic Affairs and Employment and Ministry of the Environment.

[91] Organisation responsible: Business Finland.

[92] Ministry of Economic Affairs and Employment 2021. This refers to the press release on 21.10.2021 by Finnish government titled "Innovation and Skills in Finland 2021-2027 promotes regional vitality, employment and wellbeing".

- The Finnish Environment Institute (SYKE) has prepared a plan for a material flow analysis and for implementing scenario work in support of the agreement in collaboration with other research institutes. The work will start in March 2022 and continue until the summer of 2023. Ministries have been seeking partners to low-carbon circular economy agreement. [93]

2.1.1 Key issues and next steps

Key issues mentioned about Finland's circularity advancement are:

- develop legislation and product policy measures that support the circular economy[94]
- promote a stronger market for recycled materials[95]
- improve the attractiveness of circular economy services[96]
- enhance circular economy innovations, digitalisation and skills[97]
- monitor the progress of the circular economy[98]
  - attitudes and operating models that support the circular economy.
  - domestic material consumption
  - raw material consumption
  - resource productivity
  - circular material use rate
  - eco-innovations
    - innovative public procurement
    - municipal, packaging, and construction waste volumes and recycling rates

The National Waste Plan, approved by the Government, defines waste management objectives for 2023 and measures for achieving these objectives.[99] The Government

[93]Ministry of the Environment 2022b. Partners being seeked are sectoral organizations, companies, counties, municipalities and other stakeholders. They are invited to participate in the preparation of a voluntary agreement on a low-carbon circular economy and to become partners to it. The agreement is part of Finland's National Circular Economy Programme, and the aim is to promote the transition to a low-carbon circular economy society in different sectors. The aim is that the stakeholders will join the agreement on a low-carbon circular economy by making commitments of their own.
[94] Ministry of the Environment 2022c.
[95] Ministry of the Environment 2022c.
[96] Ministry of the Environment 2022c.
[97] Ministry of the Environment 2022d.
[98] Ministry of the Environment 2022e.
[99] Environment 2022.

Programme also proposes several measures aimed at preventing the generation of waste and promoting the recovery of waste material. Finland has also drafted a national strategy for reducing the landfilling of biodegradable waste.[100] Plastics Roadmap for Finland also defines the actions for circularity.[101]

2.1.2 Barriers identifies for CE in Finland[102]

a. views on the concepts of bioeconomy, circular economy and sustainability vary according to which parties are involved.
b. difficult to make new circular business models profitable.
c. lack of infrastructure for resource optimization e.g. processing.
d. environmental permits do not consider circularity e.g. side streams, i.e. mostly focused on companies' emissions.
e. there are tighter requirements for circular economy products than virgin materials.
f. current laws slow development or act as barriers for circularity development e.g. the case of organic certification.

2.2 Ireland

The Whole of Government Circular Economy Strategy is Ireland's first national circular economy strategy.[103] The Strategy is a key addition to Government's drive to achieve a 51 percent reduction in overall greenhouse gas emissions by 2030 and to get on a path to reach net-zero emissions by no later than 2050, as per commitments in the Programme for Government and the Climate Act 2021.[104] According to the Irish government, meeting climate targets requires a transformation in the way that Ireland produces and uses goods. Transition away from fossil fuels and energy efficiency measures are considered to only address 55 percent of Ireland emissions, with the remaining 45 percent coming from **product manufacturing and processing.**[105]

---

[100] Ministry of the Environment 2022f.
[101] Muovikartta 2022.
[102]Näyhä A 2019., Näiriäinen N., Soppela J. 2021., Taivanlantti T. 2019., FORI 2021., Maaseuduntulevaisuus 2020., Metsänomistajat 2019., Näriäinen N. 2021b.
[103] Government of Ireland 2022., Government of Ireland 2021.
[104] Government of Ireland 2022.
[105] Government of Ireland 2022.

Table 1. Key facets of circularity in businesses as defined in Ireland's CE strategy[106]

Design for Circularity	Process in which companies aim to re-design their products and associated business models to enable the retention of embedded value. Design for Circularity is aligned with Eco-Design and seeks to anticipate and minimize negative environmental impacts associated with manufacture, use and disposal of products. The designs give priority to design principles and strategies which enable materials, components, and products to have multiple use-lives in the economy.
Product-Service-Systems (PSS)	Describes the transformation of a traditional product offering into a product-service model where ownership of a product is retained by the manufacturer or distributer. In PSS, end-users are given access to products through pay-per-use, short-term rental, or long-term lease models. Central to successful PSS are products that are designed for; longevity, and backward and forward compatibility, utilize predictive maintenance and have an enabling service network which ensures high-quality performance.
Re-Use & Shared Use	Refers to when a product or component is used again for the same purpose. Shared Use refers to collaborative consumption (e.g. Peer-to-Peer or B2C) or asset sharing (B2B). New B2B business models are emerging which facilitate the sharing of overcapacity of business equipment and even the underutilized skills and knowledge of personnel. Re-Use and Shared Use are cornerstones of the circular economy because they increase the utilization of products across multiple use-lives.
Remanufacturing	Remanufacturing is when a used product is returned to the standard of an equivalent new product. Remanufacturing involves the disassembly, restoration, replacement and testing of the individual components and the product itself to ensure it complies with its original design specifications. Remanufactured products come with warranties assuring that products meet like-new performance standards. These warranties are at least equal to that of a newly manufactured equivalent.
Repair & Refurbishment	Process through which apparent faults and product malfunctions are rectified. Refurbishment goes a step further and entails activities to refinish and sanitize a product, so it is fit to serve its original function. Refurbishment results in a product that is in good condition but is not directly comparable with a new or remanufactured product. While important resource-life extension strategies, neither repair nor refurbishment guarantee the product will perform like new.
Take-Back Schemes & Reverse Logistics	Programmes implemented by companies to recover products or packaging from end-users so they can be repaired, re-used, remanufactured, or recycled to recover the embedded value in raw materials. Take-Back Schemes are underpinned by what is referred to as Reverse Logistics. Reverse Logistics refers to when goods move from end-users back to the retailer/distributor, original manufacturer or a third-party repair, re-use, or recycling organization.
Industrial Symbiosis	Collaboration between two or more geographically close companies whereby residuals or by-products of one industry or industrial process become the raw materials for another process within a manufacturing site (Closed-Loop Production) or industry. Industrial Symbiosis includes: the capture, recovery, and re-use of waste

[106] CIRCULÉIRE 2022.

	(materials, water, or energy) and the development of secondary raw material markets and logistics networks to facilitate by-product exchange or co-product development.
Recycling	Collection and processing of discarded materials and transformation into secondary raw materials. There are three types of recycling – mechanical, thermodynamic or energy recovery. Mechanical refers to when residuals are mechanically transformed without changing their chemical structure. Thermodynamic (chemical) involves breaking materials into their molecular components to create raw materials for new products. Energy recovery by combustion – a last resort – is when waste is transformed into usable heat, electricity, or fuel.

In Ireland, the Circular Economy Programme builds on the work of its National Waste Prevention Programme as a strong advocate for circular economy and waste prevention.[107] According to the government, circular economy can have positive environmental, economic and social impacts, such as reduced plastic pollution, new jobs, and better quality, longer lasting, consumer products.[108] Initial actions on **food waste in supply chain** and **businesses** are focused on: (a) the roll-out of a **standardised measurement methodology to measure food waste** and develop national sectoral benchmarks and, (b) **building capacity for action on food waste prevention through upskilling and case studies.**[109]

According to the Circular Economy Programme 2021-2027 - The Driving Force for Ireland's Move to a Circular Economy (EPA 2021), is also exploring the further integration of environmental licensing, to steer the circular economy, by strengthening waste and resource efficiency within the environmental regulatory framework and EPA licences as a means of promoting circularity in industrial processes, and contribute to a reduction in industrial waste generation. EPA additionally supports the measures outlined in national waste policy to optimise Article 27 notifications and Article 28 applications, which include a potential role for local authorities in the **assessment of certain by-product notifications and end-of-waste applications**; the **introduction of fees**; and **national end-of-waste applications for identified priority waste streams.** The strategy states that the outcomes of current Circuléire partnership supporting innovation for circular manufacturing in SMEs and large companies (ought to end in 2022) will be reviewed by the Circular Economy Programme in advance of new partnerships within this sector.

[107] EPA 2021.
[108] Government of Ireland 2022.
[109] EPA 2021.

Opportunities for future development in this are stated to include additional **focus on the service sector and new circular business models** (Product-Service Systems).

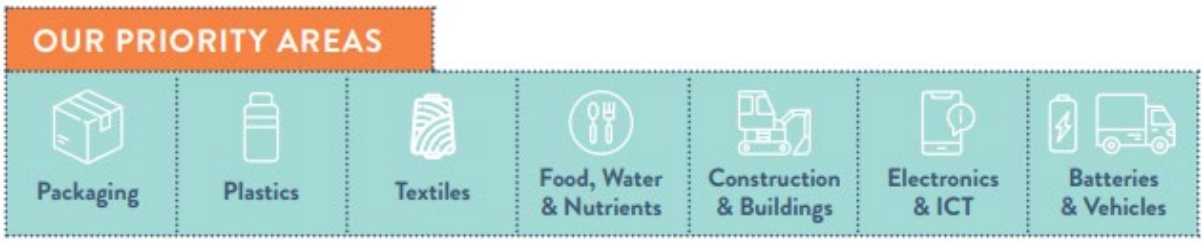


Figure 2. Priority areas as mentioned in Ireland's Circular economy programme 2021-2027.[110]

Irelands 'Waste Action Plan for a Circular Economy' is considered an action plan that will place Ireland at the forefront of EU efforts, and a roadmap for Ireland to embrace the opportunities in becoming a circular economy in the decade ahead.[111] The Strategy was a specific commitment in the Waste Action Plan for a Circular Economy (WAPCE) aiming to set a course for Ireland to transition across all sectors and at all levels toward circularity.[112] The WAPCE shifted focus away from waste disposal and towards preservation of resources by creating a circular economy. This Strategy explores the opportunity for circularity, establishing a policy framework that can help turn a vision of circularity into tangible actions and results. The Strategy explains the significance of circular economy for Ireland, Ireland' need to achieve circularity, and how national policy will develop to support the goal. Specifically, the overall objectives are:

- To promote public sector leadership in adopting circular policies and practices.
- To support and implement measures, in both absolute terms and in comparison, with other EU Member States, so that Ireland's rate is above the EU average by 2030; measures to address facets of sustainable production and consumption most impactful in an Irish context.
- To raise awareness amongst households, business and individuals about the circular economy and how it can improve their lives.

[110] EPA 2021.
[111] Government of Ireland 2020.
[112] Government of Ireland 2021.

- To support and promote increased investment in the circular economy in Ireland, with a view to delivering sustainable, regionally balanced economic growth and employment.
- To identify and address the economic, regulatory and social barriers to Ireland's transition to a more circular economy.[113]

This first Strategy is stated to proceed on a non-statutory basis, and upon enactment, the Circular Economy Bill will place the Circular Economy Strategy on a statutory footing, making the ongoing development of circular economy policy a legal requirement of Government.[114]

2.2.1 Key issues and next steps

The overarching objectives of the action plan is to:

- shift the focus away from waste disposal and treatment to ensure that materials and products remain in productive use for longer thereby preventing waste and supporting reuse through a policy framework that discourages the wasting of resources and rewards circularity;
- make producers who manufacture and sell disposable goods for profit environmentally accountable for the products they place on the market;
- ensure that measures support sustainable economic models (for example by supporting the use of recycled over virgin materials);
- harness the reach and influence of all sectors including the voluntary sector, R&D, producers / manufacturers, regulatory bodies, civic society; and
- support clear and robust institutional arrangements for the waste sector, including through a strengthened role for Local Authorities (LAs).[115]

The government also hopes to take the necessary steps to include green criteria and circular economy principles in all public procurement.

[113] Government of Ireland 2021.
[114] Government of Ireland 2022.
[115] Government of Ireland 2020.

2.2.3 Barriers identified in CE in Ireland

(a) **lack of public awareness about what the circular economy is,** how it relates to everyday purchasing and consumption decisions, and the potential environmental, health and economic benefits associated with increased circularity. This translates into lack of demand, then acts as a drag on investment in the circular economy.

(b) **businesses** are aware of the circular economy as a concept but **lack confidence to invest in circular products or services**. This could be due to concerns regarding, for example, a perceived lack of quality in re-used or repaired goods or doubts as to the environmental credentials of nominally 'green' products.

2.3 Norway

Norwegian economy is estimated as only 2,4 percent circular which is a rather high circularity gap.[116] Estimate is that over 97 percent of all the materials consumed in the country is not cycled back into the economy.[117] According to a recent global analysis, Norway is one of the countries at greatest risk of a decline in GDP in a scenario where the world is not able to transition to a sustainable economy.[118] Based on a comprehensive assessment of the potential for increased circularity by Deloitte, and given the Norwegian industry structure and resource base, agriculture, forestry, aquaculture and fisheries, process industry, and retail were the five of seven industries that emerged as significant for circularity.[119] These were considered in the forefront of the EU's action plan due to their potential, direct or indirect impact, of close to 50 percent of waste streams in Norway.[120] The waste management and recycling industries were also considered able to play a key role in triggering the potential for a circular economy by facilitating higher levels of sorting, reuse and material recycling, and by offering secondary raw materials on the market, while transport and distribution important nexus in ensuring a good flow of raw materials and goods.[121]

---

[116] Deloitte 2020.
[117] Circular Norway 2020. p.6
[118] Circular Norway 2020.
[119] Deloitte 2020.
[120] Deloitte 2020.
[121] Deloitte 2020.

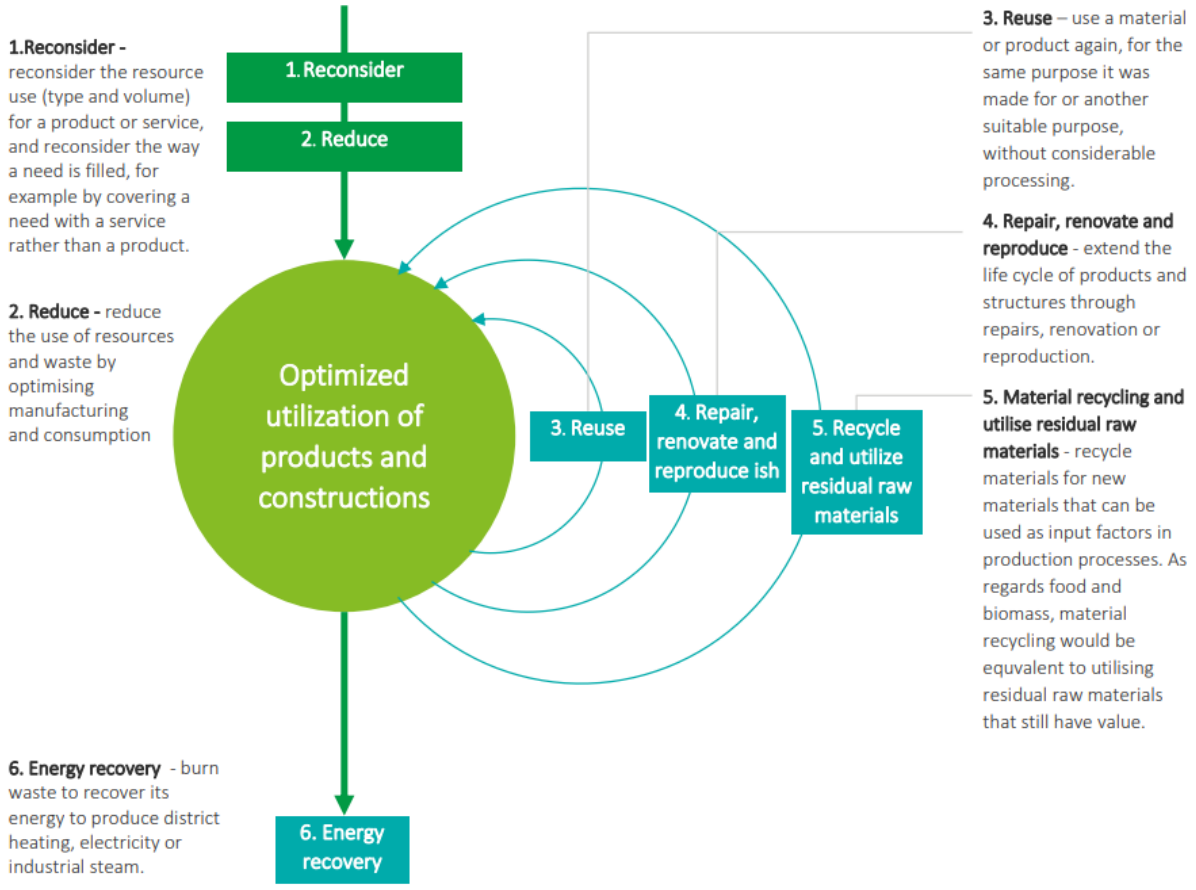


Figure 3. Strategies for a more circular economy as depicted for Norway[122]

The Government's ambition is for Norway to play a **pioneering role** in the development of a green, circular economy that makes better, more efficient use of resources.[123] Norway possesses huge ocean areas and **extensive expertise in sustainable aquaculture**, and is the world's second-largest seafood nation, after China, with tremendous potential for further ocean harvesting and developing the ocean industries.[124] Implementation of the Circular Economy Action Plan by the EU as part of the European Green Deal is a strong driver for the shift to a circular economy in Norway.[125] As a member of the European Economic Area (EEA), Norway is indirectly subject to most EU climate change and circular economy policies and plans, such as the Green Deal and the Circular

[122] Deloitte 2020. p.12.
[123] Deloitte 2020.
[124] Theexplorer 2020.
[125] Regjeringen Norway.

Economy Action Plan[126], hence the initiatives that are being taken under the action plan will concurrently have major implications for Norway as well.[127] Norwegian strategy describes how EU and Norwegian policy fit together under four main headings. These are:

- developing a circular economy through sustainable production and product design,
- developing a circular economy through sustainable consumption and use of materials, products and services,
- developing a circular economy through toxic-free material cycles, and
- a circular economy and value creation.

The Norwegian government's strategy describes how Norway's policy fits into EU circular strategy; the EU Circular Economy Action Plan, and describes the implications of the EU action plan for Norwegian policy, for Norway's positions in its cooperation with the EU, and efforts to enhance Norway's green competitiveness.[128] The vision and overall objectives formulated in the strategy does clarify that the Government does not consider the transition to a circular economy to be a goal in itself.[129] Instead, it is viewed as a process that will contribute to value creation and sustainability and at the same time result in progress towards Norway's climate and environmental policy targets, including Norway's efforts to achieve the UN Sustainable Development Goals.[130]

Norway is stated to have already begun the transition to a circular economy. The business sector has for example worked systematically on the preparation of roadmaps for green competitiveness in various branches (including the process industries, the waste management sector, retail and wholesale trade and the packaging industry).[131] Circular solutions are a key element of the roadmaps. The Government of Norway considered having an overview of the economic sectors in Norway that have an unused potential for value creation based on circularity, and stressed involvement of business sector as a basis when preparing this strategy.[132] For this reason, a consultancy firm Deloitte was commissioned to carry out an external review to provide part of the knowledge base for

[126] Circular Norway 2020.
[127] Regjeringen Norway.
[128] Regjeringen 2022.
[129] Regjeringen 2022.
[130] Regjeringen 2022.
[131] Regjeringen 2022.
[132] Deloitte 2020.

the strategy. Deloitte was asked to involve stakeholders in the process.[133] The information in Deloitte's reports (delivered the last of three reports in August 2020) are stated to come from a meeting involving more than 50 key representatives from 12 different sectors, interest groups and research institutes; written input from almost 90 different stakeholders; interviews; and a review of a wide range of written material, including the roadmaps for green competitiveness drawn up by various business and industry sectors.[134]

Deloitte's review describes opportunities and challenges that will arise in connection with the development of a circular economy in Norway, and identifies the sectors and cooperation between sectors that offer the greatest potential for value creation in a more circular economy. From the report, construction and buildings; the process industries; wholesale and retail trade; and the **bio-based sectors (agriculture and forestry, and aquaculture and fisheries) are considered most important sectors for circularity**. A need for complete circular value chains in the production of seaweed and kelp are also mentioned. The review also identifies barriers that may prevent the potential for greater realization of circularity in these sectors, while outlining policy instruments that can be used to promote the transition to a more circular economy. Using the strategy for developing a green, circular economy as a basis, the Norwegian government will:

- make use of local and regional resources and industry structures throughout the country in developing a circular economy;
- support the Norwegian industrial sector in making use of opportunities to enhance its green competitiveness in a circular economy;
- promote a development pathway in which circular solutions within the bio-based sectors and more use of renewable resources to replace non-renewable alternatives to make the greatest possible contribution to progress towards climate and environmental targets and to sustainable value creation;
- use legislation and targeted initiatives to enhance circularity in building construction and operation. The central government manages a large property portfolio and has a special responsibility in this area;
- safeguard Norway's interests in connection with the development of the EU's product policy framework for more sustainable products;

[133] Deloitte 2020.
[134] Deloitte 2020.

- support initiatives for high climate and environmental standards as a basis for more sustainable products and value chains under the EU Circular Economy Action Plan;
- seek to enhance Norway's green competitiveness by making use of the potential of a circular economy;
- enhance the role of the recycling industry in managing material resources and as a supplier of secondary raw materials for use in material cycles;
- work towards toxic-free material cycles by pursuing an ambitious chemicals policy in cooperation with the EU;
- use the potential of digitalization to make product information and information on markets for secondary raw materials available to all stakeholders;
- take initiatives for research-based knowledge generation and innovation. The public agencies in the research, innovation and technology development system will be tasked with further developing the circular economy as a cross-cutting focus area of their activities;
- develop a broad-based knowledge base on how economic instruments can be used to promote better resource use and the development of a circular economy;
- promote sustainable consumption and green innovation in the public sector through the public procurement system;
- and strengthen consumer rights and make it easier for them to adopt circular consumption patterns. The Government is seeking to widen the availability of products that are more durable and more sustainable in other ways, and to improve consumer information. The Government will provide more support for Ecolabelling Norway's work on the circular economy.

2.3.1 Key issues and next steps[135]

The key issues and next steps in Norway are:

- to promote technology development and make Norwegian industry more competitive, the Norwegian Government will cooperate closely with the EU on further development of waste legislation and product legislation, and on access to shared funding instruments.

[135] Regjeringen 2022.

- the Government will take steps to enable retailers, wholesalers and other service industries to market circular products and solutions to a greater extent than at present.
- government will expand Norwegian involvement in the development of global standards for a circular economy.
- construction and buildings sector are stated to generate low direct but large indirect emissions, e.g., by generation of large quantities of waste, and use of construction products. Maintaining buildings and other structures and lengthening their lifetime, and returning to the cycle for re-use a larger proportion of building materials are considered of utmost importance. The Government is preparing better guidance on the re-use of building materials, and is considering changes to national requirements so that they do more to promote re-use.
- the Government also considers it increasingly important to make use of the potential of digitalization e.g. digital business passports in the shift to a circular economy. Digital marketplaces, for example for secondary raw materials or for sharing assets, are important for promoting re-use and the use of secondary raw materials.

2.3.2 Barriers identified for CE transition in Norway[136]

a. Regulatory/ political:
    - current regulations are designed to regulate activities in a linear economy. There are unclear regulatory definitions of what constitutes a resource and what constitutes waste. Further, there are restrictions regarding which entities are allowed to utilize resources defined as waste.
    - there are multiple instances where the accounting, taxation, and excise system favours "consumerism" rather than increased utilization of existing resources.
b. Economic:
    - insufficient size of material to utilize for products consisting of secondary and circular materials.
    - the greatest barrier to the transition to a circular economy is that it can be difficult to make new circular business models profitable.
c. Technological:
    - digital immaturity in multiple industries.

[136]Regjeringen 2022., Deloitte 2020.

- lack of digital infrastructure for resource optimization.
- lack of technology and systems to handle and utilize secondary raw materials.

d. Structural barriers:
   - lack of cooperation within and across industries, value chains.
   - small volumes of material and waste streams, spread across large geographical areas.
   - lack of or inadequate data for material and waste streams (volumes, content and quality).
   - insufficient profitability in establishing infrastructure and systems for collection, sorting and material recycling.

e. Knowledge:
   - insufficient use of complete life cycle analyses to calculate the overall environmental impact of products and processes.
   - general confusion surrounding the differences and similarities between terms such as circular economy, sustainability, climate-neutral, green growth and transition.

2.4 Scotland

A preliminary examination of the opportunities for a circular economy in Scotland was made and document available.[137] The report outlines the circular economy potential for Scotland, the current barriers needing intervention, and outlines how opportunities for a circular economy can be created.[138] "Making Things Last" is Scotland's approach in its Circular Economy Strategy. There are two key elements of this strategy that the Scottish government hopes to use to bring together all sectors to work together towards a more circular economy. The first is a better approach to producer responsibility – ensuring that provision for dealing with products at the end of their lives is fully taken into consideration when they are placed on the market, and the other hopes to tackle the country's food waste, i.e. a reduction target of 33 percent by 2025 for action along the whole supply chain.[139] The Circular Economy Bill for Scotland, one of the bills

[137]Ellen MacArthur Foundation 2022.
[138]Ellen MacArthur Foundation 2022.
[139]Scottish Government 2016.

that was to be initiated, was later on stated as one of the Bills that will not be progressed.[140]

Still Scotland's waste regulation was ratified for all organizations, whether private public or voluntary. Since 1 January 2014, the Scotland Waste Regulations has been in force, with all organizations operating in Scotland, big and small, required to recycle key waste fractions. Most food businesses will also have to recycle their food waste.[141]The regulations require that any and all organizations in Scotland present the following materials for recycling: Glass (including drinks bottles & rinsed empty food jars); Metal (including cans, tins); Plastic (including, drinks bottles & rinsed empty food containers); Paper; Cardboard; Most urban food businesses will need to present food waste separately for collection.[142] Urban food businesses (such as cafés, restaurants or food take-aways) which produce over 5 kg of food waste per week also have to present food waste separately for collection unless excluded by a rural location. Businesses can use a postcode finder tool to check whether their business area is considered to be rural or non-rural area. The Scottish government defines food business as "An undertaking, whether for profit or not, and whether public or private, carrying out any activity related to the processing, distribution, preparation or sale of food"; this excludes businesses which only prepare and sell drinks.[143]

2.4.1 Key issues and next steps

The government of Scotland follows a very similar circularity concept as the one used in Ireland (see table 1). The key steps to be taken are as follows:

Waste reduction:

- introduce a new Scottish food waste reduction target: To reduce all food waste arising in Scotland by 33 percent by 2025 and work with industry to reduce on-farm losses of edible produce.
- support SMEs to both prevent food waste, and adapt to the new 5kg threshold for separate food waste which came into force in January 2016.

[140]Circular Online 2020., Ellen MacArthur Foundation 2022.
[141]Ellen MacArthur Foundation 2022.
[142] Ellen MacArthur Foundation 2022.
[143] Zero Waste Scotland 2022.

- work with the construction sector to ensure building designs consider waste reduction in both new build and refurbishment, while also enabling more reuse and recycling at end of life.
- work to avoid depletion of primary aggregates and timber resources through enhanced recycling of demolition materials.

Design for circularity:

- improve awareness and capabilities around design innovation for the circular economy.
- support for companies in devising and implementing more circular economy business models within their processes and supply chains.
- awareness raising events and case studies showcasing business benefits of product, process and service innovation relating to circular design.
- attaching value to goods previously seen as disposable will continue to be a focus for engaging the public and helping them to understand their responsibilities as citizens

Re-use and repair:

- work to influence EU decisions on a life-cycle approach to design of products and packaging, with products designed for long lifetimes, ready to be disassembled and repaired, and eventually recycled, for example by restricting the use of toxic materials.
- work to influence EU decisions on a design of products including for repair.

Recycling and recovering resources:

- set out mandatory requirements for the separate collection of key materials, including food waste, and prohibit any separately collected material going to incineration or landfill.
- take a “whole supply chain” approach to recycling, recognizing that all players need to work together to supply and demand high quantity and high-quality recycling, identifying and working with key partners to deliver improvements.
- intend to explore how Scotland can improve the producer responsibility system to promote products that support a more circular economy, for example through increased durability and or with recycled content.
- explore the concept of a single framework for producer responsibility
- explore the scope to phase out the purchasing of non-renewable biological materials. Increasing proportion of biological wastes to be used for production of

high value materials and chemicals, maximizing environmental and economic benefits and replacing non-renewable chemical feedstocks

2.4.2 Barriers identified in CE in Scotland

- Food: In 2015, Zero Waste Scotland, a not-for-profit environmental organization funded by the Scottish Government and European Regional Development Fund, conducted a study to evaluate waste practices in Scotland titled "Sector Study on Beer, Whisky, and Fish".[144] The report identified several opportunities in the marine waste sector based on extracting value from leftover residue. The authors also highlighted a need for (a) coordinated and staged development of biorefinery strategy; (b) locally adapted innovative low-tech solutions, suitable for small scale and rural areas; (c) cross-sector awareness raising; (d) bioresources mapping; and (e) efficient data recording and sharing.[145]
- Recycling: The challenge is to increase the quantity and quality of materials recycled to support a more circular economy; while tackling contamination and working to remove poor quality and illegal activity from the sector.[146]
- Biological waste: development and innovation to address technical barriers for the use of biological waste.[147]
- Absence of fiscal incentives; poor access to capital to invest in new infrastructure and innovation; directives promoting recycling over re-use; weaknesses in financial and legal frameworks.[148]
- Awareness: lack of business awareness of commercial opportunities.[149]
- Structure of Scotland's business base and data limitation; dominated by smaller enterprises, might indicate that companies are more risk averse than those elsewhere, less ambition to grow and innovate.[150]
- Data limitations may hinder the accurate assessment of the potential impact of the circular economy.[151]

---

[144]Rudovica et. al 2021.
[145]Rudovica et. al 2021.
[146]Scottish Government 2016.
[147]Scottish Government 2016.
[148]Ellen MacArthur Foundation 2022.
[149]Ellen MacArthur Foundation 2022.
[150]Ellen MacArthur Foundation 2022.
[151]Ellen MacArthur Foundation 2022.

2.5 Summary of CE frameworks across NPA regions[152]

The challenges identified per country in line with the EU CEAP implementation across the NPA regions addressed are presented below. Across all regions are similarities with main problems being lack of awareness about circular business models and the benefits, unavailability of digital infrastructure/ technical barriers, lack of cooperation, current regulations not supporting CE transition, and general confusion surrounding the differences and similarities between terms closely related to circular economy terminology e.g. sustainability.

Norway

- insufficient size of material to utilize for products consisting of secondary and circular materials.
- lack of cooperation within and across industries, value chains.
- lack of digital infrastructure for resource optimization.
- lack of technology and systems to handle and utilize secondary raw materials.
- greatest barrier to the transition to a circular economy is that it can be difficult to make new circular business models profitable.
- small volumes of material and waste streams, spread across large geographical areas.
- Insufficient profitability in establishing infrastructure and systems for collection, sorting and material recycling.
- general confusion surrounding the differences and similarities between terms such as circular economy, sustainability, climate-neutral, green growth and transition.
- current regulations are designed to regulate activities in a linear economy. There are unclear regulatory definitions of what constitutes a resource and what constitutes waste.
- there are multiple instances where the accounting, taxation, and excise system favors "consumerism" rather than increased utilization of existing resources.

Ireland

- lack of public awareness about what the circular economy is, how it relates to everyday purchasing and consumption decisions, and the potential environmental, health and economic benefits associated with increased circularity. This

[152]EC 2020.

translates into lack of demand, then acts as a drag on investment in the circular economy.
- businesses are aware of the circular economy as a concept but lack confidence to invest in circular products or services. This could be due to concerns regarding, for example, a perceived lack of quality in re-used or repaired goods or doubts as to the environmental credentials of nominally 'green' products.

Finland

- views on the concepts of bioeconomy, circular economy and sustainability vary according to which parties are involved.
- difficult to make new circular business models profitable.
- lack of infrastructure for resource optimization e.g. processing.
- environmental permits do not consider circularity e.g. side streams, i.e., they are mostly focused on companies' emissions.
- there are tighter requirements for circular economy products than virgin materials.
- current laws slow development or act as barriers for circularity development e.g. the case of organic certification.

Scotland

- lack of locally adapted innovative low-tech solutions, suitable for small scale and rural areas.
- cross-sector awareness raising is lacking
- need for mapping bioresources.
- need for efficient data recording and sharing.
- the challenge how to increase the quantity and quality of materials recycled to support a more circular economy; while tackling contamination and working to remove poor quality and illegal activity from the sector.
- development and innovation to address technical barriers for the use of biological waste is needed.
- absence of fiscal incentives; poor access to capital to invest in new infrastructure and innovation;
- current laws and directives promote recycling over re-use
- lack of business awareness of commercial opportunities.
- structure of Scotland's business base and data limitation dominated by smaller enterprises, might indicate that companies are more risk averse than those elsewhere, thereby less ambition to grow and innovate.
- data limitations may hinder the accurate assessment of the potential impact of the circular economy.

According to the EC circular economy action plan, accessing by-products and end-of waste potentials, improving value chains, addressing systematic challenges, and reducing the waste and emissions across the EU would work through information sharing of good practices, collaboration between industries, as well as cooperation within and across industries and the EU. Regulations for priority waste streams would be additionally introduced in order to enable retaining of products in circulation as long as possible. In order to effectively support the CEAP realization, the following measures are proposed that relate to agriculture, forestry, aquaculture and fisheries sectors.

1. There is a need for cooperation that facilitates local, regional, and circular solutions where one business' waste or surplus energy can be input factors for other businesses.
    - Agriculture, forestry, aquaculture and fisheries, and the process and food industries have particularly high potential for fruitful cooperation. **Collaboration between industries**, both within and across value chains, will be decisive in creating a circular economy.
    - Major changes in both extraction and production processes, as well as consumption patterns, will be aimed at enhancing **cooperation both within and across industries and value chains to make them more circular, e.g., setting requirements for other parts of the value chain.**
    - Complete **circular value chains** in the production of seaweed and kelp.
2. Necessary to move beyond research and innovation and have a strategic and systemic approach to the deployment of innovations to fully reap the economic, social and environmental benefits of the bioeconomy.
    - bring together all actors across territories and value chains to **map the needs** and actions to be taken.
    - **addressing systemic challenges** that cut across the different sectors, including synergies and tradeoffs, to enable and speed up the deployment of circular economy models.
3. Need for changes in current regulations regarding by-products and waste fraction to drive circularity. The aim is to ensure that measures support sustainable economic models (for example by supporting the use of recycled over virgin materials). These include a potential **assessment of certain by-product notifications and end-of-waste applications**; the **introduction of fees; and national end-of-waste applications for identified priority waste streams**.
    - Extended Producer Responsibility (EPR).

- Producer liability for eco modulation of fees.
- Reusable or recyclable **packaging.**
- Introducing **digital business passports** utilization to drive circular consumption.
- **Ecolabelling of financial products** and the discussion of non-financial disclosure.

4. Need for showing exemplary circularity initiatives and empowering businesses and consumers.
    - **Good practice examples/ mentoring** e.g., from Norway and other regional countries who have developed innovative and highly skilled industries associated with the extraction, processing, and production of products from largest natural resources such as aquaculture and fisheries
    - **Enhancing visibility of actions to strengthen consumer rights** e.g., via awareness of businesses circular actions and their positive impacts, to make it easier for them to adopt circular consumption patterns.

3 Examples of good practices – natural resource circularity–regenerative actions

3.1 Products based circular practices

3.1.1 Aquaculture and fisheries

Wester Ross salmon -Company with EMS (Scotland)[153]
Founded in 1977, Wester Ross Fisheries is the oldest independent salmon farm in Scotland. As farmers, they consider themselves guardians of the natural environment as their livelihoods depend entirely on caring for the waters where its salmon grow. The company has successfully grown salmon in the same sea lochs since 1977 in harmony with many other local users and the local environment, including a designated Scottish Nature Reserve. Wester Ross salmon are stated to have one of the world's best FIFO (fish in, fish out) ratios of less than 1:1, greatly reducing dependency on wild fish growth, and no promoters or chemical supplements are used. The company is still looking at ways to reduce this further.

Figure 4. Wester Ross salmon company's sustainability communication. Among other, the farm meets ISO14001 Environmental Management standards and holds the endorsement from the Scottish Industry Code of Good Practices.

[153] WRS 2022.

Ocean Forest- integrated multitrophic aquaculture (Norway)

Lerøy Seafood Group and the Bellona Foundation joined efforts to start Ocean Forest, a collaborative company established in 2014 in Bergen, with aim of developing more sustainable seafood production while reducing the environmental footprint from aquaculture.[154] The company practices integrated multitrophic aquaculture, meaning production of new types of biomass alongside aquaculture. It uses phosphorus, nitrogen and CO_2 released from fish farms to cultivate sugar kelp and mussels, a good example of the circular economy in practice, with sustainable food production and reducing CO_2 as an added benefit.[155]

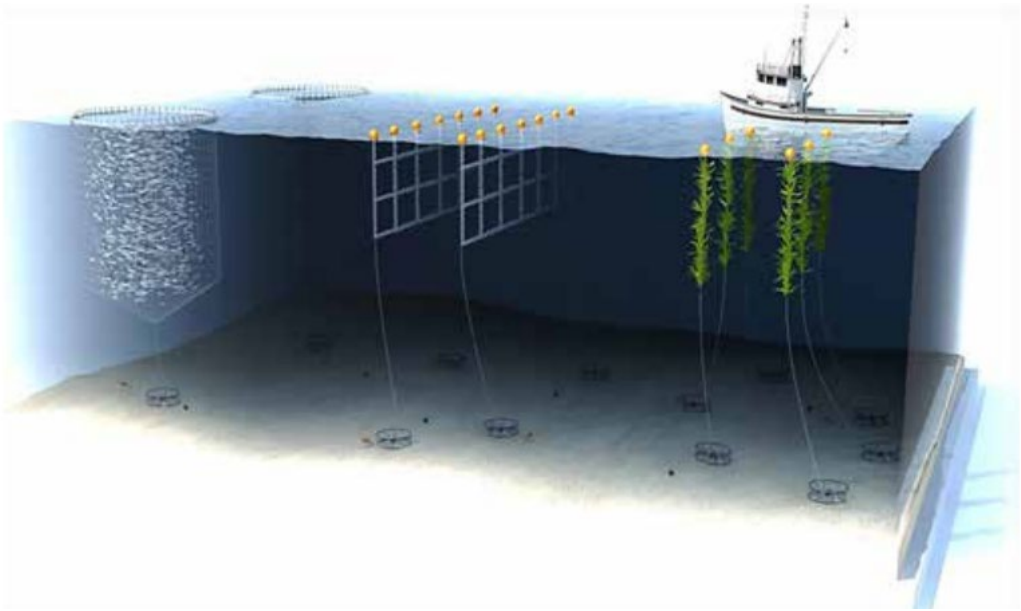


Figure 5. Illustration of the Integrated Multi-Trophic Aquaculture concept: Low trophic species like kelp and mussels are produced in proximity with higher trophic species; fed fish. Waste from one species becomes a resource for the other species. (Illustration: The Dude / The Bellona Foundation)[156]

Integrated Multi-Trophic Aquaculture (IMTA), is an ecosystem-based aquaculture that combines the culture of fed species such as salmon, with that of extractive species e.g. mussels and seaweeds, with the potential benefit to mitigate ecological effects from

[154] Oneplanetnetwork 2017.
[155] Theexplorer 2020.
[156] Bellona 2015.

fish monoculture practice.[157] Seaweeds (i.e. macroalgae) and mussels are cultivated alongside conventional fish farming, thereby utilising nutrient emissions from fish production and lowering the impact of fish farms.[158] In addition to recycling nutrients, marine biomass like mussels and seaweeds naturally bind CO2.[159] CO2 is bound to algae and shellfish (via growth of their calcium carbonate shell).[160] If performed within ecologically sustainable limits, IMTA is considered an important means to increase food security, value creation and enhanced livelihoods via solutions to increased production of local, resource efficient and climate friendly food and biomass for energy purposes while at the same time capturing CO2.[161]

Atlantic Leather, Sauðárkrókur, Iceland[162]
Atlantic leather (currently termed Nordic Fish Leather) is a family company located in North Iceland. The company, employing 19 persons, focuses on tanning and manufacturing of mainly sheep and fish leather products. They are the only tanner in Iceland and also only fish leather tannery in Europe. Atlantic Leather manufactures leather products for the fashion industry, and has been awarded several times, e.g. top tannery in Europe 2016 award. The raw materials used are mainly by-products from the food and fishing industry, and their suppliers are mostly local producers. The Atlantic leather is committed to the sustainable development and this is expressed in their website (Atlantic Leather 2019). They emphasise the use of by-products, clean geothermal energy and hot water, and correct purification of waste waters.

The stakeholder requirements from the fashion industry raise the importance of the business sustainability. The products are based on both Icelandic tradition (use of fish leather) and innovation (manufacturing of new materials). Product quality is controlled and monitored in detail, and quality classifications are in use. The process has also potential environmental impacts, which are identified and controlled, and actions of company communicated to their stakeholders and to the public.

[157] Bellona 2015.
[158] Oneplanetnetwork 2017.
[159] Theexplorer 2020.
[160] Oneplanetnetwork 2017.
[161] Bellona 2015.
[162] Okkonen, L., Klijberg, S. 2020.

Figure 6. Example of final products from salmon skins.

Otoseeds (Iceland)[163]

Otoseeds collects wasted paper, fish waste and seeds to produce a dense paper that comes to life when it is watered. The paper is used to create a collection of biodegradable products. The idea was born following the Maketahon challenge from Matís (a non-profit company) in October 2020. It was titled "How can we use organic waste from the fishing industry to make it more sustainable?". The team was made up of three individuals with different backgrounds, and they ended up winning the Makeathon challenge. The idea was to combine the tradition of papermaking and waste from the Icelandic fishing industry. They make paper by binding together ground cod bones which is phosphorus-rich fertilizer, and otoliths as pH neutralizing agent, quality paper additive and calcium-rich fertilizer. By adding seeds into the paper they have designed the next step of the zero-waste cycle – it could grow into food or flowers. Otoseeds uses design to get their message across – put the importance of sustainability and waste reduction into the spotlight.

[163] Circulareconomyloop 2022., Otoseeds 2022.

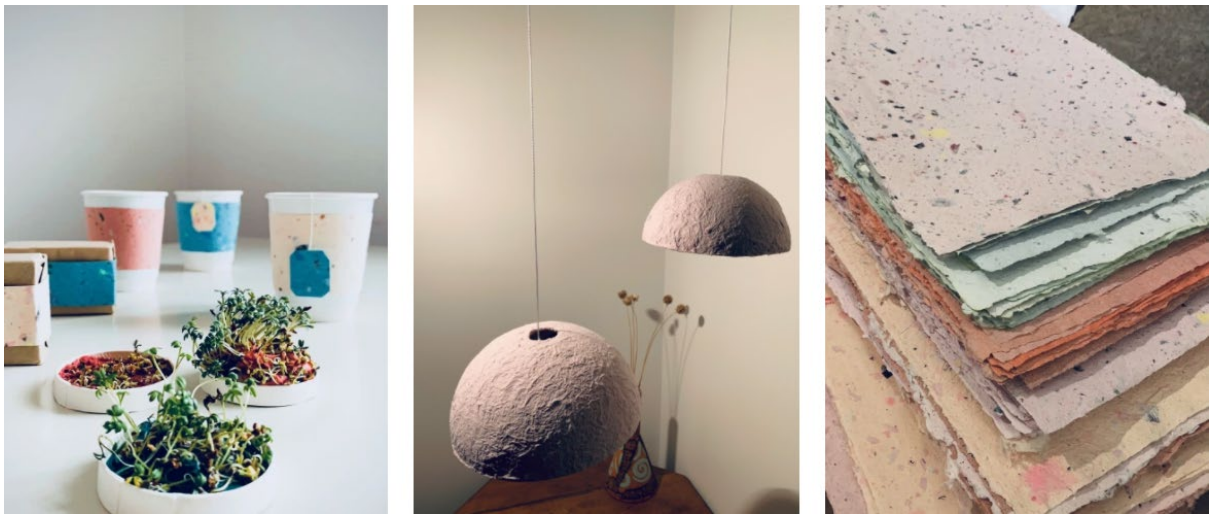


Figure 7. Examples of final products by Otoseeds.

GreenBytes (Iceland)[164] and TotalCtrl Restaurant (Norway)[165]

The restaurant sector is still very traditional; it lacks flexibility and relies heavily on guests, making it an extremely vulnerable industry, with up to 70 per cent of a restaurant's costs related to food inventory and labour, and 4 to 10 per cent of the purchased food wasted before it is served.[166]

GreenBytes offers planning tool for restaurants to reduce food waste by maximizing the ordering process. The cloud-based solution helps restaurants organize raw material orders by calculating how much of each raw material is needed using itemized menu and artificial intelligence that predicts upcoming sales. The machine learning algorithms application helps organize menus, tracks inventory, and predicts future raw material needs. Considering previous sales, weather and other factors, the application calculates amount of raw material needed in e.g., upcoming week, informs the restaurant, and if the restaurant finds the recommendation viable, they approve the order for the various raw materials which automatically notifies all their distributors.

TotalCtrl Restaurant also promotes sustainable operations by providing restaurant owners and employees with digital control over food inventory. However, its concept is totally different from GreenBytes. When a food delivery has arrived, staff use TotalCtrl

[164] Greenbytes 2022.
[165] Theexplorer 2022c.
[166] Theexplorer 2022c.

Restaurant to confirm that the invoice matches the delivery. This ensures that the restaurant has the correct quantity and type of goods, as well as an overview of the expiry date for each item. The solution sends notifications when items are about to expire, enabling staff to prevent food waste. The comprehensive inventory overview prevents over-ordering, delivered goods are efficiently confirmed, staff can quickly locate items and expiry dates are tracked. The solution is available as a yearly subscription with full customer support. According to the explorer site, restaurants have reduced the amount of time used on monthly inventory by up to 90 per cent. In addition, the explorer site states that there are over 15 million restaurants worldwide, a market value of around USD 3.25 trillion, with serviceable addressable market for TotalCtrl Restaurant in Europe alone estimated at roughly USD 550 billion. TotalCtrl Restaurant is already used by over 600 restaurants around the globe. In Norway, the solution is also used by after-school programmes and nursing homes.

Waister (Norway)[167]

Wet waste creates a lot of costly logistics, often it causes smell, spills and can attract insects and rodents as it deteriorates fast. Additionally, logistics related to wet waste handling is rather intensive with frequent collection and the need/ use of specialized trucks. Wet waste is also generally difficult to recycle or reuse and has traditionally been dumped in landfills. This has meant both waste of resources as well as a source of greenhouse gas emissions.

Waister is a company based on the idea of transforming wet waste into reusable products – From wet waste to value. Waister enables reuse and upcycling of wet waste fractions through superior drying technology which turns wet waste into storable and transportable raw materials thereby creating opportunities to upcycle it to plus products. Examples are bio-fertilizers, biogas booster, feed ingredients or pet food ingredients.

Figure 8. Types of food waste used by Waister.

[167] Waister 2022.

BioCHOS AS (Norway)[168]

BioCHOS AS was established in 2013 and is a spin-off company from the Norwegian University of Life Sciences. BioCHOS is developing in cooperation with industrial partners a plant protection products containing antifungal chitosan oligomers.

BioCHOS´product is a new active substance for plant protection products. It inhibits the growth of fungal diseases on crops. The active substance is chitosan oligomers (CHOS). CHOS is made from chitin-rich by-products from the shellfish industry. It is termed a natural product that is safe to use for farmers, consumers and the environment. CHOS is currently being tested as an ingredient in a range of new plant protection products. Since it is a non-toxic and natural product, it can be registered for use both in organic agriculture and as a supplement to conventional fungicides in traditional agriculture.

3.1.2 Forest and agricultural raw material, side streams, by-products

Aurora Sustainability (Scotland)[169]

Aurora Sustainability recovers coffee waste and heat from whisky distilleries to produce and supply dry fresh mushrooms. The end product, made entirely from waste, also improves Scottish biodiversity in terms of CO2 capture, as mushrooms can increase tree growth three-fold.

Ogilvy Spirits (Scotland)[170]

Scotland's first Potato Vodka producer, making vodka from potatoes not suitable for retail.

FoodsforNorway (Norway)[171]

New research performed in the centre for research-based innovation Foods of Norway at the Norwegian University of Life Sciences (NMBU) shows that feed based on novel ingredients from the Norwegian forest can have an effect on the microbiota in pigs' guts. Through several trials, the research team found that the alternative feed increased lactic acid-producing bacteria in the small intestines of the pigs, which may protect young

[168] Theexplorer 2022d., Biochos 2022.
[169] Zerowaste Scotland 2022b.
[170] Ogilvyspirits 2022.
[171] NMBU 2021.

pigs from common infections. The trials were based on a diet where yeast replaced up to 40 per cent of protein ingredients, which in this case was compared with a conventional soy meal-based diet. The findings (though not yet commercialized) show that feeding pigs a novel diet with yeast from spruce trees as the protein source may have a positive impact on their intestinal health.

Jaw Brew (Scotland)[172][173]

Jaw Brew, in partnership with Aulds the Bakers, has created a zero-waste low alcohol beer from leftover bread rolls. The "Hard Tack" beer is now available for purchase around Glasgow.

Peel Tech (Scotland)[174]

Peel Tech is a Scottish invention which takes waste from a typical potato peeler separating waste skin and compacting potato starch so that drains are free from waste and peelings can be used for animal feed. The technology is being rolled out across typical "Fish and Chip" shops across Scotland and helps businesses comply with Waste Regulations.

Bay Fish and Chip Shop (Scotland)[175]

Bay Fish and Chip Shop is an award-winning fast-food retailer committed to managing waste effectively. Food waste is recycled, turned into compost by a local farmer who grows the potatoes from which the shop makes its chips. All waste fuel is converted into bio-fuel, packaging is recyclable and compostable, and staff are trained about the company's environmental programmes and incentivised to develop sustainable ideas. Over a twelve-month period they prevent 6,300kg of waste from going to landfill and have saved 56 tonnes of CO2 from being released into the environment.

Biovotec [176]

Biovotec has developed a product for treating chronic wounds sourced from eggshell membrane discarded by the food industry. Biovotec's novel medical device incorporates Purified Eggshell Membrane Protein, or PEP™. PEP™ consists of micron-sized protein particles, produced from the lining of domestic chicken eggs, a by-product of the

[172] Jawbrew 2022.
[173] Jawbrew 2022b.
[174] Peeltech 2022.
[175] Zero Waste Scotland 2022.
[176] Biovotec 2022.

food industry. By tapping into an existing value chain PEP™ can be sourced at a low cost, while maintaining the highest quality and safety standards.

CelluComp -root vegetables nanofibers into paints and coatings (Scotland)[177]
CelluComp is a Scottish-based company located in Fife, near Edinburgh. Its team of scientists and business professionals work on the development and commercialisation of sustainable materials. Its main activity is to develop and commercialise Curran®, a material developed from the extraction of nanocellulose fibres of root vegetables, primarily from sugar beet pulp, which is a by-product of the sugar industry. Curran® offers exceptional mechanical and rheological properties for numerous applications, such as paints and coatings, inks, personal care, home care, paper, food, concrete, drilling fluids, composites and other potential applications.

Honkajoki (Finland)[178]
Honkajoki manufactures raw material for biofuels and pet food from the side streams sourced from slaughterhouses. In Finland, the aim has always been to use the non-edible part of meat production as much as possible. Honkajoki was established in 1967 to enhance the use of animal-based raw materials produced by slaughterhouses. The core of the operation has been the same for 50 years, but the technology has developed and the purposes for which the side streams are used have changed.

The company receives approximately 75 per cent of all animal-based side streams in Finland. It separate's protein and fats from the by-products they have bought from slaughterhouses, which are thereafter used in the manufacture of biofuels and pet foods for example. By processing the animal-based side stream further, the company makes products with high value from animal-based side streams that are otherwise wasted and taken to landfills or incinerated.

Decreasing consumption of meat has currently dominated conversations. However, as long as people eat meat, a solution for using the considerable side streams it generates is important. Animal-based raw materials also have their strengths. For example, a study commissioned in Finland showed that the life cycle of protein made from animal-based side streams produces lower emissions as part of pet food than exported soya.

---

[177] Cellucomp 2022.
[178] Honkajoki 2022., Sitra 2021.

In some drugs, an animal-based ingredient cannot even be replaced by anything else. The company is also constantly investigating the possibilities to use new side streams other than meat.

Storaenso (Finland)[179]

Stora Enso is a leading global provider of renewable solutions in packaging, biomaterials, wooden construction and paper. It has been a pioneer in the forest and related sector. A well-known example of its products is "Pure by Stora Enso", a wood-based dissolving pulp that is being used as a raw material in the textile industry. This has been used for example in making iconic evening gown made by Aalto University for Finland's First Lady Jenni Haukio to wear at the 2018 Finnish Independence Day Reception (photo 1). Stora Enso from North Karelia province, supported the new method of producing textile fibres developed by Aalto University and the University of Helsinki and supplied dissolving pulp as the raw material for the project. The textile fibre used in Haukio's gown was produced using the new Ioncell method.

Figure 9. Jenni Haukio's gown that has been produced using the new Ioncell method (© Forest.fi)[180]

[179] Storaenso 2022., Storaenso 2013., Storaenso 2018.

[180] Forest 2018.

Up to 70 percent of textiles are manufactured from non-renewable petroleum-based fibers, while the share of cotton, the main alternative to oil-based fibers, has come down to 20 percent. Cotton is a natural fibre, but its cultivation requires a high amount of water. As an example, making one pair of cotton jeans takes about 7000 litres of water, while producing the same jeans using the Ioncell technology only requires 3 percent of that amount. The water saved, 6790 liters, equals about the amount of water a person would consume over ten years. Additionally, to maximize crops yield, traditional cotton farming uses fertilizers and pesticides which can damage local eco-systems.

The use of wood-based fibres in the textile industry is only 6 percent. They entail a higher cost compared to polyester and cotton. However, wood-based fibres are the only fibres in the world that combine the advantages of cotton and petroleum-based fibres, meaning good moisture management and brightness. These facilitate printing detail and a long-lasting pattern. In addition, viscose fibres have a unique set of properties i.e. lustre and drape, that no other fibre can deliver.

Since 2012, Stora Enso has focused on understanding the textile value chain better. They are working on development projects such as the Ioncell technology, on which they collaborate with Aalto University, Helsinki University and Marimekko to try and revolutionise the fashion industry with circularity (renewable and recyclable fibre and a transparent value chain). For their part, Stora Enso is at the very beginning of the value chain and they can ensure a sustainable and renewable raw material, whereas at the other end of the value chain, Marimekko creates and provides long-lasting and high-quality designer textiles.

Spinnova (Finland)[181]

The textile industry is one of the world's biggest contributors to negative environmental impacts. For example, enormous amounts of water are used in cotton cultivation. In addition, industrial chemicals pollute the soil and water systems.

Spinnova makes textile fibres from pulp. According to the company website, it is the only company in the world that can produce textile fibre without a chemical dissolution process or harmful chemicals. They ship in surplus material, grind it mechanically into microfibre and manufacture textile fibre from the microfibre and water. The company

[181] Sitra 2021b., Spinnover 2022., Pusu 2022.

focuses on two raw materials: paper pulp and waste leather. Spinnova fibre can be used to manufacture yarn, thread and fabrics for a variety of applications. They can modify the fibre to create desired properties in the finished fabric.

The company is also a good example of partnerships for circularity. In manufacturing its cellulose-based textile, Spinnova has partnered with Suzano, a Brazilian enterprise that is one of the world's leading pulp companies. Waste generated from leather production is manufactured into textile fibres in collaboration with the Danish footwear company Ecco. The company is also collaborating with companies such as Marimekko, Best seller, The North Face, H&M, Adidas and Icebreaker. Bergans, a Norwegian outdoor clothing brand, is already selling clothing made from their fibre. World's first skis enforced with revolutionary SPINNOVA® fibre have also been made as collaborative effort between Spinnova and Pusu Oy.

Figure 10. Left (Textile fibre from pulp), Rest (Examples of fabric based on the fibre being turned into products).

The company has also tested other source materials, which showed potential of **producing textile fibre from agricultural waste such as wheat and barley straw**. They could also make new fibre from recycled textiles, such as used cotton garments, hence their aim is to apply these processes in the future.

N2 Applied (Norway)[182]

N2 Applied has developed a technology that enables local production of fertiliser using only livestock slurry, air and electricity, dramatically reducing harmful emissions and improving yield at the same time. The technology adds nitrogen from the air into slurry, which increases the nitrogen content. The reaction prevents the loss of ammonia and

[182] N2Applied 2022.

eliminates methane emissions.[183] The N2 Unit from N2 Applied can help farmers produce their own fertiliser from livestock slurry, air and electricity. The unit adds nitrogen from the air into the slurry, thereby increasing the nitrogen content. The process improves organic fertiliser by stopping the loss of ammonia and increasing the fertiliser value. This optimises crop production. Secondly, it stops methane emissions and prevents ammonia emissions, which cause global warming and reduce air quality. This is important because when slurry is spread on the field, much of the nutritious nitrogen it contains usually evaporates into the atmosphere as ammonia or leaches into the soil as nitrates.

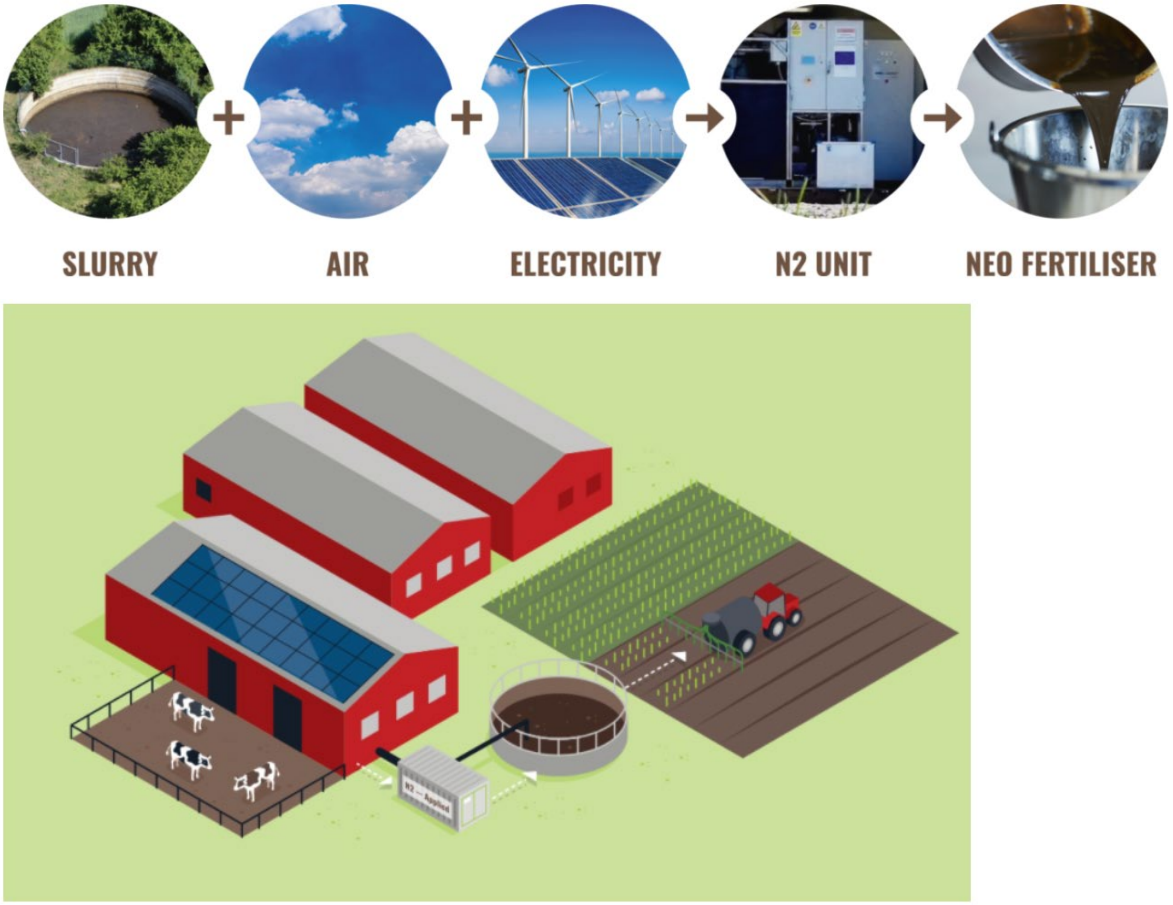


Figure 11. N2 Applied fertilizer production process. The process is stated to produce zero emissions from manure management, close nitrogen cycle in farming and saves land use expansion.

[183] N2Applied 2022. Screenshots from company website.

Field trials have been done from Northern Norway to Africa and the trials have shown that on average, crop yield is around 40 per cent higher with NEO fertiliser than with untreated manure. N2 Applied has received the maximum funding amount from the European Innovation Council (EIC) Accelerator (EUR 17.5 million), and currently has machines in the Netherlands, Norway, Sweden and the UK. [184]

Yara eco Oy -formerly Ecolan (Finland) [185]

Yara is stated as a world's leading crop nutrition company and a provider of environmental and agricultural solutions. Yara partners with farmers worldwide to optimize crop yields, reduce environmental impact and improve crop quality and nutritional value. Its fertilizer products are precisely formulated to provide targeted nutrition to suit each specific situation. It recognizes that soils, crops and climates are unique and that different fields and crops have different nutritional requirements. The company also offers digital tools for crop monitoring (measures the nitrogen status, variable-rate fertilization).[186] Ecolan (now part of Yara group) produces fertilisers and construction materials from ash generated in the burning of biomass, coal or peat in the energy industry.

Ecolan actions are stated to have originated in a cowshed. The founder, Hannu Tukiainen used to be a helicopter pilot, whose job included the aerial application of fertilisers to forested land. Ecolan's story began when Hannu started testing ash-based forest fertilisers in a cowshed in Liperi, North Karelia. The work grew in the early 2000s as forestry firms became involved in the co-operation. Now, they have also expanded their business from forestry to other industries.

The business consists of three parts: the processing of industrial side streams for forest fertilisation, for use as an agricultural pasture fertiliser and for earth construction; a forest fertiliser application service; and the acquisition of side streams. The side stream acquisition service is stated as an effortless solution that enables the use of industrial side streams in a cost- and material-efficient way.

[184] Theexplorer 2022.
[185] Yara 2022.
[186] Atfarm 2022.

Soilfood[187]

Soilfood processes fertilisers and soil improvers from industrial side streams. The nutrients processed from the side streams also bind carbon to soil. The idea came up while the owner was working at the largest dairy farms in Finland noticing how much manure is generated as a by-product on a dairy farm. Manure contains nutrients, but it is too weak to be a good fertiliser as such. Soilfood offers products that can be used to increase or balance the nutrient content of manure and this way process it into a better fertiliser. They have now introduced the same idea to using and processing industrial side streams.

Soilfood makes use of the fibre-rich and nutrient-rich side streams created in industrial production. Currently, they use side streams from the forest, food, bio and chemical industries. For example, they use the side streams created in the processing of potatoes, sugar beets and sugars and the slurries of the forestry industry, which bind carbon and nutrients to the field. They already receive side streams from approximately 50 factories in Finland, Sweden and Estonia. Before this, industrial side streams were incinerated or taken to landfills.

Woodly[188]

Woodly has redesigned plastic, which means it produces clear plastic packaging made from wood cellulose sourced from sustainably managed forests– technically a creation of novel plastic. After environmental problems caused by plastic became common knowledge approximately five years ago after huge amounts of plastic waste floating in the oceans were shown in the media, the company began to solve the problem together with its partners, such as VTT Technical Research Centre of Finland. In the awakening of plastic waste amounts, brands across the globe promised to replace their plastic packaging with more ecological packaging. However, they never defined the material that this packaging would be made of. Woodly found out that plastic is often a superior material in packaging (e.g., light, durable, transparent -visual marketing) and therefore decided not to start replacing plastic, but to redesign it. The design process was not easy as they faced challenges such as being told that they would not succeed with phrases like– 'plastic cannot be made of wood, at least not in Finland, and there is no way it can be clear'.

[187] Sitra 2021c.
[188] Sitra 2021d.

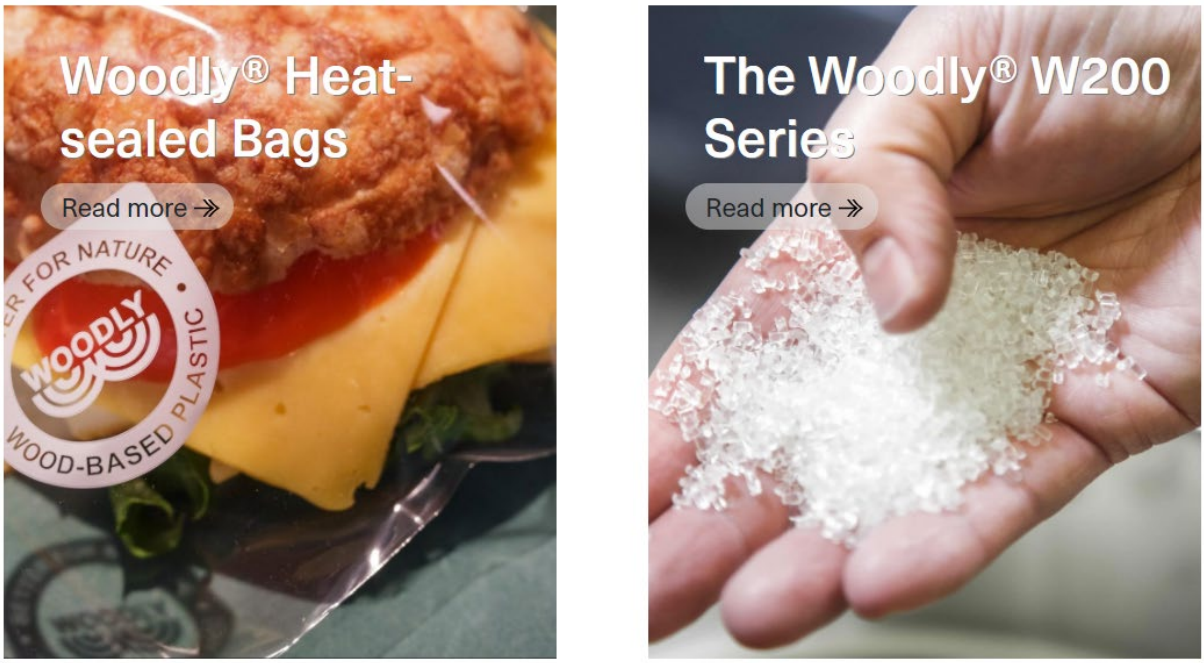


Figure 12. Woodly's superior wood-based plastic package made from wood cellulose.

Today, shops sell products in packaging made of Woodly – the clear plastic based on wood cellulose that should not have been possible to manufacture. Woodly is a granule similar to a plastic granule. The company has a recipe for it and the patent. They market it, but they are not responsible for the production themselves. Woodly is sold to companies as a raw material for packaging. They can change the production of their packaging over to Woodly partners, or Woodly will support their partners in changing over to Woodly. Changing over to Woodly's material does not require new factories or new technology, the process merely runs on existing machines. This way they make the sustainability commitments of brands reality.

Woodly can become the biggest and best-known novel plastic in the world. They want to achieve a significant share of the global market. With a larger volume, thay can increase the proportion of wood in the material. In theory, Woodly can already be made entirely from wood, but with current volumes, it is still too expensive, hence they also incorporate other materials in the manufacture.

The company's material can be recycled together with plastic packaging. However, an ideal situation, according to them would be that is be distinguished as a fraction of its own, which is currently problematic because the produced amounts being too small for that. Based on their tests, small amounts of Woodly could also be processed together

with plastic.[189] Woodly has also tested the properties of recycled Woodly and they are excellent from textiles to composite. Recycled Woodly can also be used in different plastic films, which is good news because the markets after recycling are crucial."

Kotkamills[190]

Kotkamills make paper from the sawdust generated by its own sawmill and other nearby sawmills and use the wood chip side stream of the sawmill in the manufacture of paperboard. In 2016, it began producing paperboard with barrier properties, meaning that the material is resistant to liquids and grease, for example. The board is easily recyclable and can replace plastics in packaging. The company's circular economy model is based on several intertwining circular economy solutions. Of its product portfolio:

- Absorbex® Eco saturating kraft paper utilises recycled corrugated board (old, corrugated containers, OCC) in addition to sawdust pulp as raw material. OCC is processed in their own fibre recycling plant into recycled fibre pulp,
- The final product, Absorbex® Eco is used in the production of high-pressure laminates for the construction and furniture industry, among other applications. Companies in its value chain have established their own sustainability goals in which circularity plays an important role, meaning consumer travels back through the brand owners and the converters and then finally onto the mill again as a raw material producer.

Their by-products can be seen for example in large public events and in paper cups (KLIX Eco Cup™) used in the Lavazza coffee vending machines.

Figure 13. Kotkamills example of refined value chain where side streams are used to produce range of new products.

[190] Sitra 2021e., Kotkamills 2022.

Vegware (Scotland)[191]

Vegware are the only company In the UK to develop, manufacture and distribute a full range of completely compostable food packaging and catering disposables.

Paptic Ltd (Finland)[192]

Paptic Ltd (or Paptic Oy) is a high growth company established in 2015 with headquarters in Espoo, Finland. The company has developed Paptic®, a fibre-based, and recyclable material to replace plastics in packaging. Since December 2018, renewable, reusable, recyclable Paptic® materials have been available for sustainability-oriented brand owners & retailers. The company has already delivered the material to over 40 countries. The material is based on softwood pulp and is used in responsible packaging that replaces disposable plastic packaging. Paptic combines the best features of paper, plastic and fabric: flexibility, durability, strength and recyclability. Once a bag or other form of packaging made from Paptic has reached its end, it can be recycled as packaging paper or cardboard. Paptic is used in shopping bags, shipping envelopes used by online retailers and product packaging, which currently consist around 200 Finnish and foreign retail chains. The company actions are strongly based on circularity and also shows a very good example of company transparency and marketing circularity of a company; Paptic® is made of renewable raw materials from sustainably managed forests. It is available as FSC® certified.

Figure 14. Paptic final product packaging solutions with renewability, reusability, and recyclability features.

[191] Vegware 2022., Zero Waste Scotland 2022.

[192] Paptic 2022. Sitra 2021f.

Celtic Renewables (Scotland)[193]

Celtic Renewables patented low-carbon technology converts unwanted and low-value biological material into high-value renewable chemicals, sustainable biofuel, and other commercially and environmentally valuable commodities.[194]

3.1.3 Plastic and other waste fractions from forest, agriculture, marine & aquaculture

Plastplan (Iceland)[195]

Plastplan is a small startup founded by product designer Björn Steinar and Brynjólfur Stefánsson in 2019. The goal of Plastplan is to fully recycle all plastic materials, which means completely processing plastic into new times, not just bury or burn them. Plastplan receives all 7 types of consumer plastic. Some of the products they have been creating are glass mats, flowerpots, multipurpose screws and utensils. Today, Plastplan is working directly with Icelandic retail companies in a very circular economic way. They receive their plastic waste and create products that the same retailer has requested and then sell it back to them.

[193] Celticrenewables 2022.

[194] Zero waste Scotland 2022b., Fiksuruoka 2022.

[195] Circulareconomyloop 2022., Plastplan 2022.

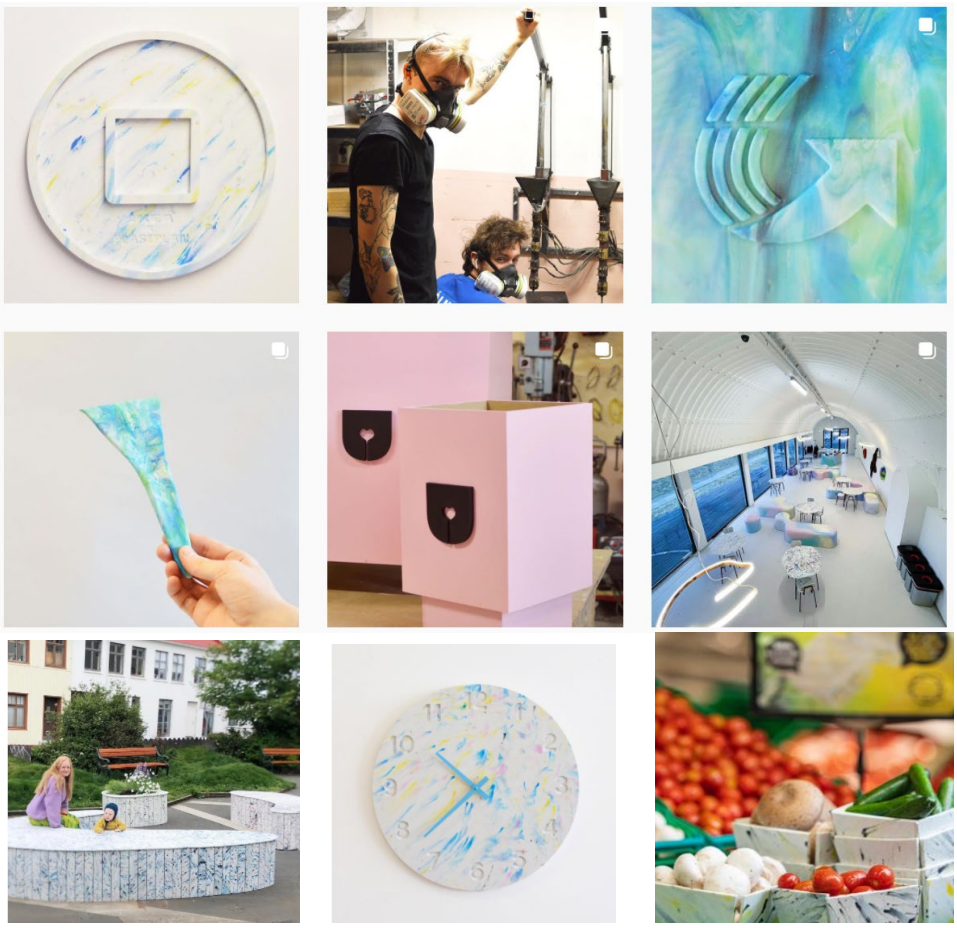


Figure 15. Plastplans recycled products. The company receives all 7 types of consumer plastics.

Nordic Comfort Products & Architecture and design firm Snøhetta (Norway)[196]
Nordic Comfort Products (NCP) believe that it is necessary to switch the current call to plastic, from seeing it as a cheap and disposable material to treating it as the robust and reusable material. The other aim was how to trigger more awareness of the problem and educate younger generations through an object of design. The solution came from northern Norway. Its innovative and sustainable fish farming industries such as Kvarøy Fiskeoppdrett and Nova Sea are stated to have been cornerstone companies that provide wealth to and maintain human settlements in local communities.

After visiting fish farms, it became clear that the industry's most difficult waste was plastic waste, such as fishing nets, ropes and pipes. These are valuable resources that can be used for other arenas. When the components are worn out, they can be

[196] Theexplorer 2022e., NCP 2019.

collected, processed and then ground into a granulate that can be injected into new shapes, generating endless possibilities for developing new objects. From that came the idea of making a chair made from recycled plastic farming waste. A chair that communicates the journey of the plastic material, from use in fishing facilities, to chairs, and then to other products when the chair has completed the life cycle.

Figure 16. The chair is made of made of 100 per cent recycled plastic from worn-out nets, pipes and ropes provided by local fish farming companies Kvarøy Fiskeoppdrett and Nova Sea, and the chair's subframe is made of recycled Norwegian steel (recycled steel by the company Celsa Armeringsstål, located in Nordland County). The chair is a redesign of Bendt Wings classic R-48 chair.

The goal of this new way of doing things is both to inspire large industries to make changes in how they produce and reuse valuable surplus material and to engage younger generations through a product that they can relate to in everyday life. The characteristic colours of the fish nets and other used plastic waste – yellow, blue and green – blend beautifully into a dark forest green shade similar to marble, so no additional colour is needed. Moreover, because no new raw materials are used, the chair has one of the smallest carbon footprints in its market segment – five to eight kg of CO_2, cradle to grave.

O-I (Scotland)[197]

Glass is an ideal package for the circular economy. More than 80 percent of the bottles that are recycled are used to make new bottles with recycled content. Glass is infinitely recyclable without loss of quality, making it a permanent material that can offset the need for raw materials as often as it is recycled. Recycling glass can for example help glass container and fiberglass manufacturing plants remain competitive and protect jobs, while reducing carbon emissions and energy use.

O-I company currently produces around 2 million bottles per day and up to 800 million annually. They do this using up to 20 percent recycled flint, 70 percent recycled green and 25 percent recycled amber glass. While many recyclables rely on export markets, the end market for its recycled glass is primarily local. Most glass customers and suppliers are within 300 miles of production plants. Glass captured from curbside recycling in one community is often processed and delivered to glass manufacturers in the same area to create new glass packaging to serve the community.

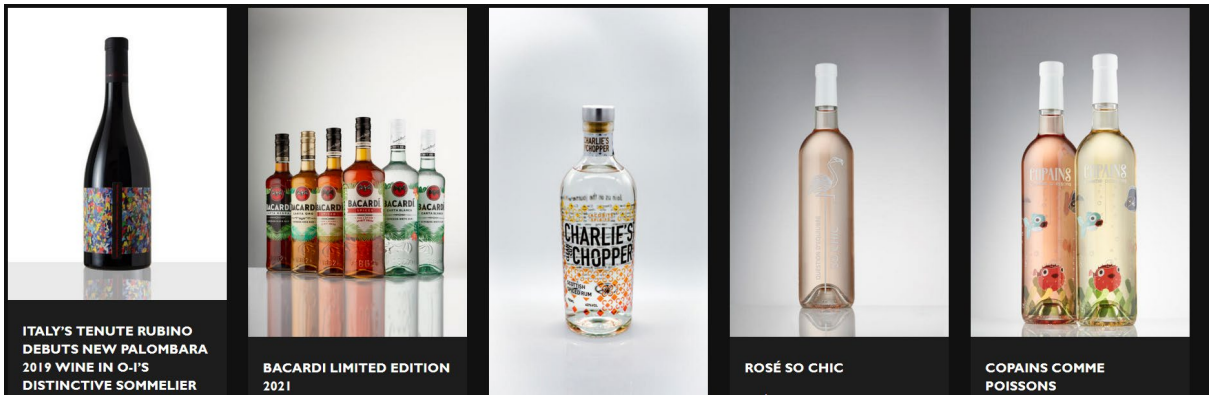


Figure 17. Example of bottles produced by O-I.

O-I has several targeted initiatives aimed at growing and improving glass recycling; from providing community grants, to purchasing infrastructure and promoting best practices to improve environmental and economic impacts.

[197] O-I 2022.

3.2 Circular services and cooperation solutions

Kamupak (Finland)[198]

Kamupak offers durable containers takeaway solution for restaurants and grocery stores as an action towards reducing disposable packaging waste. Once used, containers can be returned to Kamupak, where one can either exchange the container for a new one, redeem the deposit as a refund, or redeem the digital KamuCredit Kamupak application.

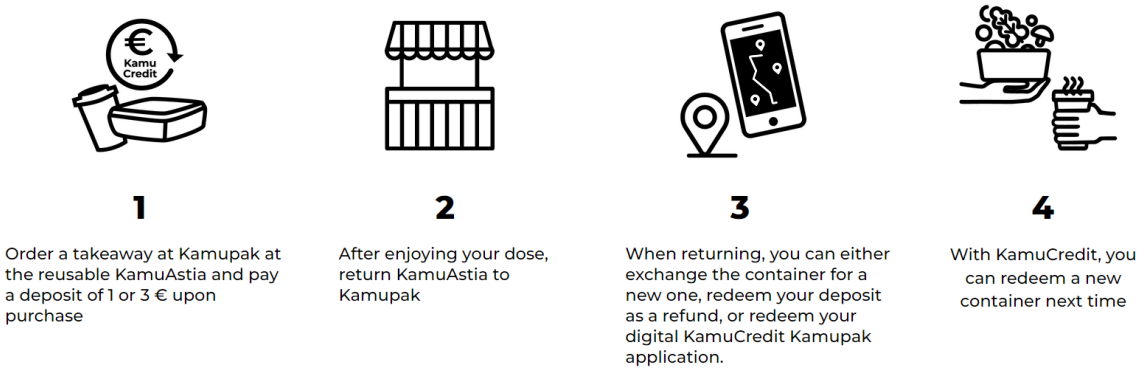


Figure 18. Kamupak's concept in reducing disposable packaging waste.

Royal Botanical Gardens (Scotland)[199]

Royal Botanical Gardens is famous with over 700,000 visitors a year from around the world. It produces over 2 tonnes of food waste weekly which is taken to anaerobic digestion.

Fiksuruoka (Finland)[200]

Fiksuruoka buys surplus food from manufacturers and sells it online to consumers at affordable prices. The company has already reduced food waste by millions of kilograms. The other co-founder, Richard Lindroos, worked in logistics for years and saw how much waste was created in all sectors. He started to investigate how the surplus could be reduced profitably and had an idea about an online store for surplus food. In the beginning, their warehouse was in Richard's garage, from where they took the orders to the post office themselves after day at work. Today, they offer 1,500 products

[198] Kamupak 2022.
[199] Zero waste Scotland 2022c.
[200] Sitra 2021g.

that they buy from wholesalers and food manufacturers. Typically, the food will be going to waste because its best-before date is approaching, the product has been removed from the product range or the packaging has changed. In four years, the company has grown from a garage warehouse to a company with a turnover of 12 million euros. This proves that their business model is profitable and the idea is scalable.

Timberyard (Scotland)[201]
Timberyard is a small Edinburgh city centre restaurant preoccupied with preventing waste across every aspect of their operations, i.e., to the tiniest of detail. The whole restaurant was thought with circularity concept from the design-building stage through to service design (materials, equipment, etc). Food is sourced mainly from local artisan producers, they filter the region's tap water and use refillable glass bottles (no plastic bottles). Of all produced waste fractions, including food waste, over 90 percent are separated and recycled. Its suppliers recollect packaging waste, and their old menus are recycled. The company is interested in ideas of how to improve actions within the restaurant.

3.3 Examples of support platforms, websites, incentives, tools etc

Food Tech Platform (Finland)[202]
An Allied ICT Finland ecosystem aimed at creating the leading food focused growth research – business network.

Create platform (Finland)[203]
crEATe is an innovation platform orchestrated by VTT, Compass Group Finland and IBM and open to actors interested in new business opportunities around food and eating. Its mission is to develop vitality-enhancing, personalised and sustainable food and eating solutions that are meaningful to consumers, clients and communities. The innovation platform facilitates development of new solutions, technologies and business models.

---

[201] Zero waste Scotland 2022c.
[202]Foodtech 2022.
[203]Createfood 2022.

Food & Beyond collaboration platform (Finland)[204]
Developed in collaboration with the Finnish agrifood community, the Food & Beyond collaboration platform aims to gather all the Finnish agrifood professionals with their unique approaches to drive food transformation and be the place for networking. It is made for sharing one's team's story, telling what's cooking, seeking and announcing collaboration opportunities, and ideating with people with the same goal: making the future brighter with sustainable food solutions.

The explorer (Norway)[205]
Showcases and drives ideas of green and sustainable solutions from Norway's key sectors: Energy, Ocean industries, High technology, Health, Bio and Natural Resources, Architecture and construction, Smart cities, Education, Circular economy, Transportation, and Food Production Systems.

Zero waste Scotland (Scotland)[206]
Zero Waste Scotland is focusing on where, as a society, they can have the greatest impact on climate change. Main listed:

- **Responsible Consumption** – where people and businesses demand products and services in ways which respect the limits natural resources.
- **Responsible Production** – where a circular economy is embraced by businesses and organizations which supply products and services to get the maximum life and value from the natural resources used to make them;
- **Maximizing Value from Waste** – where the environmental and economic value of wasted resources and energy is harnessed efficiently.

GoZero waste directory of Ireland (Ireland) [207]
The aim of this project is to provide an online platform to assist consumers and businesses reduce their plastic consumption and waste through everyday choices and action. Go Zero houses information about bulk food stores, the shops offering refill options, plastic-free markets, zero waste events, workshops and news articles & tips – making it easy for people to take steps towards a Zero Waste lifestyle.

[204]Foodand beyond 2022.
[205] Theexplorer 2022f.
[206] Zero Waste Scotland 2022d.
[207] Go Zero 2022.

CIRCULÉIRE (Ireland)[208]

CIRCULÉIRE is a public-private partnership created by Irish Manufacturing Research and the Department of the Environment, Climate and Communications (DECC), the Environmental Protection Agency (EPA), and EIT Climate-KIC with 25 Founding Industry Members. Between 2020 and 2022, CIRCULÉIRE aims to take manufacturers and their supply-chains on a journey from linear to circular business models through baselining, auditing, business case development and deep demonstration innovation projects delivering significant reductions in greenhouse gas emissions (GHGs) (Scope 1, 2 and 3) and in waste production across the network.

Smart farming partnership (Ireland)[209]

Smart Farming programme focuses on eight key areas that offer the greatest savings to farmers and reduction of greenhouse gas emissions at farm level. The programme aims to save participants €5,000 through introducing resource efficiency measures on their farm. The offer challenges to farmers, e.g., where farmers that participate receive a free resource efficiency assessment with tailored advice from an agronomist for their farm business (incl. also a cost-saving study, silage quality analysis, domestic water analysis, carbon navigator and nutrient management plan free of charge). A Smart Farming agronomist visits the farms and work with farmers to find ways to save money and take practical actions to improve resource management. The partnership is open to any farmer who is looking for advice on changes they can make to farm more sustainably. Smart Farming participants are stated to have improved resource efficiency, reduced costs and cut their emissions. For example, an average cost savings of €5,600, and average greenhouse gas emission reductions of 9 percent was identified for farmers that participated in Smart Farming in 2020.

Circle Economy (International; nordics)[210]

As an impact organisation, Circle Economy connects and empowers a global community to create the conditions for systemic transformation. It works alongside businesses, cities and governments to identify opportunities to make the transition to the circular economy, and provides a powerful combination of practical and scalable solutions to turn these opportunities into reality. Its mission is to empower the global community of businesses, cities and governments to accelerate the transition to the circular

[208] CIRCULÉIRE 2022b.
[209] Smartfarming 2022., EPA 2021.
[210] Circle Economy 2022.

economy through practical and scalable insights and solutions that address humanity's greatest challenges.

Loop (Iceland)[211]
On a mission to take circular economy from strategy to action, LOOP activates interested parties' circular business opportunities, and connect them with people and companies that will help them succeed, so technically mentorship. Using the right set of tools they release creativity and raise awareness of solutions that may help advance actions towards circularity, after which they then help transform the visions and ideas into profitable and sustainable business. Partners consist: Nordic Innovation Org, Verona Growth Finland, Antrop Sweden, Startup Norway, Startup Iceland, Agens Norway, Sitra Finland.

Iceland ocean cluster (Iceland)[212]
The Iceland Ocean Cluster's mission is to create value and discover new opportunities by connecting entrepreneurs, businesses and knowledge in the marine industries.

Sustainability leap (Finland)[213]
Sustainability leap is a database of impressive solutions hoped to encourage Finland mitigate climate change, build a circular economy and protect country's biodiversity. The website is maintained by the Finnish Environment Institute.

Discover seafood UK[214]
The Fishmongers' Company's Fisheries Charitable Trust works to build and safeguard a prosperous and sustainable fishing industry, for the benefit of those engaged in it, the environment and its island nation. Central to this is helping the public learn more about local seafood and sustainability. In 2014 it launched Fish on Friday, a seafood blog designed to celebrate everything great about British seafood and the men and women who catch it. Now, 6 years later, they have decided to build on the stories and recipes from Fish on Friday to create a more regionally focused site, connecting consumers to local fishermen and seafood, and supporting coastal communities and businesses. They want everybody to discover the remarkable stories behind the seafood on their

[211] Circulareconomyloop 2022b.
[212] Iceland ocean cluster 2022.
[213] Sustainability leap 2022.
[214] Discoverseafood 2022.

plates, to know where to buy it in a way that supports the local fishing fleet, to know which species to enjoy each season, and to be able to prepare and cook seafood which makes the most of its amazing taste and flavours. Discover Seafood gives seafood communities a platform from which to tell their stories.

Figure 19. Interactive map that tells gives communities a platform to tell and share stories connecting consumers to local fishermen and seafood.

3.4 Environmental Management System frameworks, models

The Finnish Industrial Symbiosis System (FISS) operating model (Finland)[215]

FISS is a practical tool for promoting Circular Economy, bioeconomy and regional development. It provides a systematic way to help companies and other organisations create partnerships and new business opportunities through more efficient use of raw materials, technology, services and energy that create competitive higher value in products and services. The national coordinator is Motiva Oy.

[215] Interreg Europe 2022.

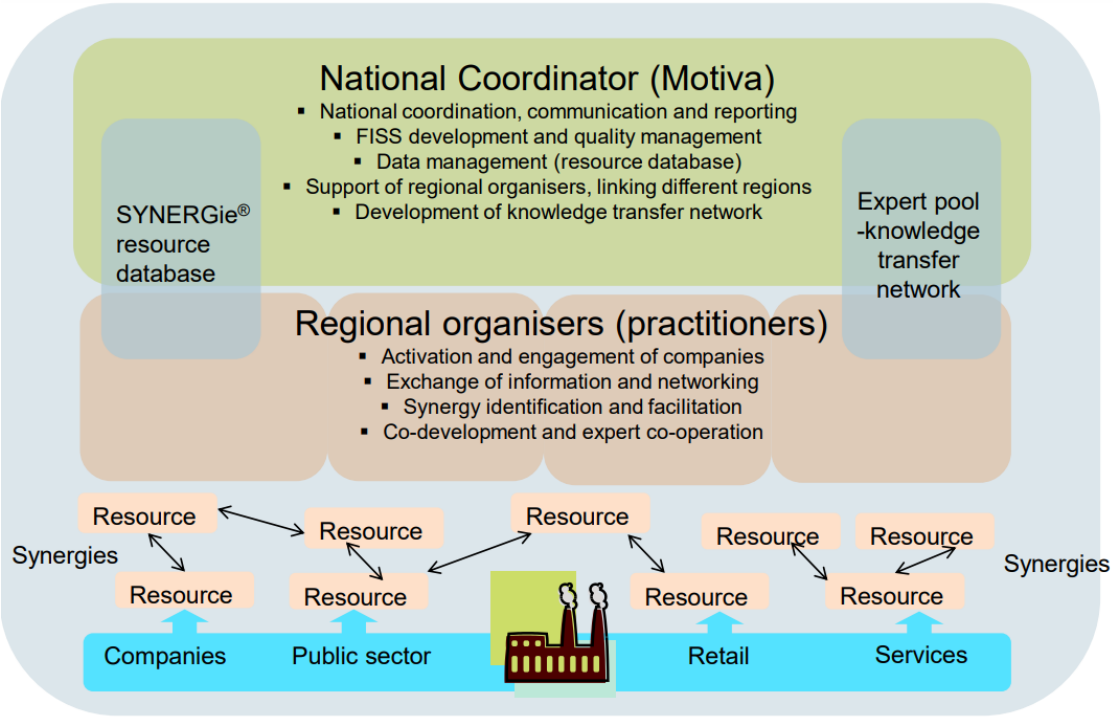


Figure 20. The Finnish Industrial Symbiosis System (FISS) operating model.

Enpros Oy (Finland)[216]

Provides services for waste environmental reporting (emissions and waste). It can be used for example by company that has multiple restaurants, offices, etc for comparing waste amounts from the various places that can help structure actions towards zerowaste. The company is located in Joensuu. It provides services for service companies, industries e.g., in manufacturing and production, as well as logistics and handling companies.

[216] Zerowaste 2022.

4 Conclusions

The annual extraction of natural resources has tripled since 1970, and with this, greenhouse gas emissions are rising, and large parts of the world are facing considerable waste and pollution issues. For example, forests are the largest land-based natural resource in Europe with increasing demands to use this resource for many different purposes. Biomass and land area are already scarce resources complicating the need to feed and produce raw materials for products, while reducing greenhouse gas emissions at the same time. Residue and waste (e.g., food, fishing gear, packaging materials, etc) are also problematic waste fractions impacting on biodiversity and climate. The rate and ways of natural resources exploitation from among other, agriculture, forests, marine and fisheries, have presented the need for more sustainable and efficient use of resources and prioritising, meaning a shift to circular economy is considered inevitable. The Circular Economy Action Plan based on the Green Deal has hence been introduced with the aim that resource efficiency is enhanced through circular value chains that reduce waste and/or utilize waste (e.g. side streams, by-products) as resource.

In the EC's Circular Economy Action Plan, one way of ensuring circularity in natural resource use and biodiversity conservation (agriculture, forest, aquaculture and fisheries) is through regulations and policy actions that drive circularity. In the plan, the Commission will:

- **reinforce the mandatory essential requirements for packaging to be allowed on the EU market** in order to ensure that all packaging on the EU market is reusable or recyclable in an economically viable way by 2030.
- propose **mandatory requirements for recycled content and waste reduction** measures for key products such as packaging in order to increase uptake of recycled plastics and contribute to the more sustainable use of plastics.
- ensure the timely implementation of the new **Directive on Single Use Plastic Products** and fishing gear to address the problem of marine plastic pollution.
- **introduce rules on measuring recycled content in** products that will be developed for the first time.
- enable Member States to use **value added tax (VAT) rates to promote circular economy** activities.
- enhance **disclosure of environmental data by companies** in the upcoming review of the non-financial reporting directive.

- support a business led initiative to **develop environmental accounting principles** that **complement financial data**.

The implemented regulatory measures and other initiatives have been prioritized for the seven important sectors termed "key product value chains. Five out of the seven product value chains directly impact marine and fisheries, and forest and agriculture raw material extraction, and processing sectors, which explains how these have been framed in country specific strategies looked at in chapter 2 of the report.

Within the CE framework, marine and fisheries, farmers and forest natural products (i.e., extracted, collected from forests, not logging), and related industries producers face two, seemingly contradictory challenges: the need to feed and produce raw materials for products for millions of people, and reduce greenhouse gas emissions at the same time. On one hand, biomass and land area are already scarce resources and will be in increasing demand in a circular zero-emission economy, as carbon from renewable sources such as trees are good replacement for fossil resources, both for fuel and as raw material in the production of various products. For marine and fisheries, the geographical position of the Northern Periphery and Arctic places is at crossroads in the light of Climate Change, biodiversity discussion and ongoing circularity regulatory frameworks. With a geography and climate largely unsuited for land-based food production, and with no or limited access to arable land due to glacial ice and barren rocks, many coastal communities and countries of the Northern Periphery and Arctic traditionally live from the sea. In addition, areas with climate largely unsuited for land-based food production as a result of geographical location has meant that effects from climate change in coastal areas are mainly driven by anthropogenic CO2 emissions. This is especially evident in the coastal region and has, in some areas, resulted in losses of biodiversity and unpredictable changes in availability of important marine food species.

Across all three coastal cases for marine and fisheries studied in this report, food waste and marine litter are considered waste fractions that need addressing, even though the level and scale of actions defined differ per country. The problem with marine and fisheries side streams are also given high priority across all regions with these termed as "waste" to be handled throughout business value chains. In agriculture and forest resources use, resource efficiency and food security are highlighted tracing from the need for securing biodiversity, food production and enhancing carbon storage. These align with the EU framework where circularity in extraction and processing of natural

resources are the main focus areas for the European Commission's (EC's) Circular Economy Action Plan.

Still, the transition to CE and/ or developing of value chains towards CE are not without challenges. Some challenges have been identified per studied country (Finland, Norway, Iceland and Scotland) in line with the EU CEAP implementation. Across all regions are similar challenges from regulatory/ political, economic, technological, structural barriers, to knowledge and awareness. The mutual problems across all regions have been lack of awareness about circular business models and the benefits, unavailability of digital infrastructure/ technical barriers, lack of cooperation, current regulations not supporting CE transition, and general confusion surrounding the differences and similarities between terms closely related to circular economy terminologies.

According to the EC circular economy action plan, retaining products in circulation for as long as possible requires accessing by-products and end-of waste potentials, improving value chains, addressing systematic challenges, and reducing the waste and emissions across the EU. This could be accomplished through information sharing of good practices, collaboration between industries, as well as cooperation within and across industries of the NPA. In order to effectively support the CEAP realization, above measures are proposed in addition to regulations for priority waste streams.

References

Atfarm 2022. Company website. https://www.at.farm/

Bellona 2015. Environmental considerations in the Arctic: Sustainable resource exploitation. https://network.bellona.org/content/uploads/sites/3/2016/01/ArcticReport-version-2.0_web.pdf .p.94.

Biochos 2022. Company website. http://www.biochos.com/

Biovotec 2022. Company website. https://www.biovotec.com/projects

Cellucomp 2022. Company website. https://www.cellucomp.com/about/about-us

Celticrenewables 2022. Company website. https://www.celtic-renewables.com/

Circle Economy 2022. Website. https://www.circle-economy.com/about

Circulareconomyloop 2022. Circular Economy Solutions Startups in Iceland. https://circulareconomyloop.com/circular-economy-solutions-startups-in-iceland/

Circulareconomyloop 2022b. Website. https://circulareconomyloop.com/

Circular Norway 2020. The Circularity Gap Report Norway 2020. https://circulareconomy.europa.eu/platform/sites/default/files/20200826_-_cgr_nor_lite.pdf

Circular Online 2020. Scotland's Circular Economy Bill "will not be progressed" due to COVID-19 (news published 2.4.2020). https://www.circularonline.co.uk/news/scotlands-circular-economy-bill-will-not-be-progressed-due-to-covid-19/

CIRCULÉIRE 2022. What is the Circular Economy? Circularity is a new way to design, make and consume. https://circuleire.ie/the-circular-economy/#strategies

CIRCULÉIRE 2022b. The national platform for Circular manufacturing. https://circuleire.ie/

Createfood 2022. Website. http://createfood.fi/

Deloitte 2020. Study for a National Strategy for Circular Economy Short summary. p.6-12. https://www.regjeringen.no/contetas-sets/70958265348442759bed5bcbb408ddcc/deloitte_study-on-circular-economy_short-summary.pdf

Discoverseafood 2022. Website. https://discoverseafood.uk/uk-relay/

EC 2018. A Sustainable Bioeconomy for Europe: Strengthening the Connection between Economy, Society and the Environment. https://op.europa.eu/en/publication-detail/-/publication/edace3e3-e189-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-149755478

EC 2018b. Guidelines for the feed use of food no longer intended for human consumption (2018/C 133/02).

EC 2018c. New solutions to reduce marine plastics pollution around Ireland. https://ec.europa.eu/regional_policy/en/newsroom/news/2018/11/22-11-2018-new-solutions-to-reduce-marine-plastics-pollution-around-ireland

EC 2020. Circular Economy Action Plan -For A Cleaner and More Competitive Europe. p.11., p.12., p.13., p.14., p.15., p.20-21. https://ec.europa.eu/environment/pdf/circular-economy/new_circular_economy_action_plan.pdf

EC 2020b. Changing how we produce and consume: New Circular Economy Action Plan shows the way to a climate-neutral, competitive economy of empowered consumers. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_420

EC 2022. Internal Market, Industry, Entrepreneurship and SMEs. https://ec.europa.eu/growth/industry/sustainability/sustainable-product-policy-ecodesign_en

EC 2022b. Farm to Fork strategy - for a fair, healthy and environmentally-friendly food system. https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_en

Ellen MacArthur Foundation 2022. Scotland and the Circular Economy - A preliminary examination of the opportunities for a circular economy in Scotland. https://www.zerowastescotland.org.uk/sites/default/files/Scotland%20and%20the%20Circular%20Economy%20%28a%20report%20for%20the%20Scottish%20Government%29.pdf

Environment 2022. Waste – the aim is to reduce the quantity and harmfulness of waste. https://www.ymparisto.fi/en-US/Consumption_and_production/Waste_and_waste_management

EPA 2020. Chapter 8 -The Marine Environment. https://www.epa.ie/publications/monitoring--assessment/assessment/state-of-the-environment/EPA-Ireland's-Environment-2020-Chapter8.pdf

EPA 2021. The Circular Economy Programme 2021-2027-The Driving Force for Ireland's Move to a Circular Economy.

EU Newsroom 2020. New Circular Economy Action Plan shows the way to a climate-neutral, competitive economy of empowered consumers. 11/3/2020. https://ec.europa.eu/news-room/growth/items/671357

Fiksuruoka 2022. Company website. https://www.fiksuruoka.fi/

Foodand beyond 2022. Website. https://foodandbeyond.eu/food-for-thought/welcome-to-join-the-food-beyond-collaboration-platform/

Foodtech 2022. Website. https://www.foodtech.fi/index.php/materials/

Forest 2018. Haukion puvulla on pitkä historia – puutekstiilille arvokasta näkyvyyttä (Published 5.12.2018). https://forest.fi/fi/artikkeli/haukion-puvulla-on-pitka-historia-puutekstiilille-arvokasta-nakyvyytta/#efa6ea33

FORI 2021. Research data and solutions for the development of organic production in Finland - Finnish Organic Research Institute's research strategy for 2021–2024. https://luomuinstituutti.fi/wp-content/uploads/2021/01/luomuinstituutin_tutkimusstrategia_2021-2024_EN.pdf

Government of Ireland 2020. A Waste Action Plan for a Circular Economy- Ireland's National Waste Policy 2020-2025.

Government of Ireland 2021. Whole of Government Circular Economy Strategy 2021 – 2022 Pre-consultation.
https://www.gov.ie/en/consultation/37078-public-consultation-on-the-proposed-publication-of-the-circular-economy-strategy/

Government of Ireland 2022. Whole of Government Circular Economy Strategy 2022 – 2023 'Living More, Using Less'. https://www.gov.ie/en/publication/b542d-whole-of-government-circular-economy-strategy-2022-2023-living-more-using-less/

Go Zero 2022. Website - The Zero Waste Directory of Ireland http://gozero.ie/

Greenbytes 2022. Company pages. https://greenbytes.is/language/is/home/

Honkajoki 2022. Sustainability report “vastuullisuusraportti”. https://honkajokioy.fi/wp-content/uploads/2021/06/Honkajoki_vastuullisuusraportti2020_FIN_en-C1.pdf ., https://honkajokioy.fi/en/our-products/

Iceland ocean cluster 2022. Website. https://www.sjavarklasinn.is/en/

Interreg Europe 2022. FISS - Finnish Industrial Symbiosis System – Green Circular Economy. https://www.interregeurope.eu/good-practices/fiss-finnish-industrial-symbiosis-system https://www.interregeurope.eu/fileadmin/user_upload/plp_uploads/events/IndustrialSymbiosis_22_5_2019/FISS_-_Finnish_Industrial_Symbiosis_System.pdf

Jawbrew 2022. Company website. https://www.jawbrew.co.uk/

Jawbrew 2022b. About circular economy. https://www.jawbrew.co.uk/about/circular-economy

Kamupak 2022. Company website. https://www.kamupak.fi/

Kotkamills 2022. Company website. https://kotkamills.com/

Maaseuduntulevaisuus 2020. Valtaosa Suomen metsämarjoista voisi olla luomua, mutta sertifikaatti puuttuu – "Tällä hetkellä suurin ongelma on, että luomukeruualueet ovat kartalla pirstaleisia". https://www.maaseuduntulevaisuus.fi/metsa/49e373db-c7ab-5d11-aaad-c35adc61d743

Metsänomistajat 2019. Luonnontuotteista lisätuloa luomukeruualueiden sertifioinnilla. https://www.mhy.fi/paijat-hame/uutiset/luonnontuotteista-lisatuloa-luomukeruualueiden-sertifioinnilla

Ministry of Economic Affairs and Employment 2021. Press release on 21.10.2021 by Finnish government titled “Innovation and Skills in Finland 2021-2027 promotes regional vitality, employment and wellbeing”. https://valtioneuvosto.fi/en/-/1410877/innovation-and-skills-in-finland-2021-2027-promotes-regional-vitality-employment-and-wellbeing

Ministry of the Environment 2022. Strategic programme to promote a circular economy. https://ym.fi/en/strategic-programme-to-promote-a-circular-economy

Ministry of the Environment 2022b. Ministries seek partners to low-carbon circular economy agreement. https://ym.fi/en/strategic-programme-to-promote-a-circular-economy/circular-economy-in-key-sectors

Ministry of the Environment 2022c. Circular economy market - How we implement the circular economy programme. https://ym.fi/en/strategic-programme-to-promote-a-circular-economy/circular-economy-market

Ministry of the Environment 2022d. Circular economy innovations, digitalisation and skills - How we implement the circular economy programme. https://ym.fi/en/strategic-programme-to-promote-a-circular-economy/circular-economy-innovations-digitalisation-and-skills

Ministry of the Environment 2022e. How we monitor the progress of the circular economy. https://ym.fi/en/strategic-programme-to-promote-a-circular-economy/how-we-monitor-the-progress-of-the-circular-economy

Ministry of the Environment 2022f. Circular Economy – Waste. https://ym.fi/en/waste

Muovikartta 2022. Reduce and Refuse, Recycle and Replace – A plastic roadmap for Finland. https://muovitiekartta.fi/in-brief/ ., https://muovitiekartta.fi/useras-sets/uploads/2019/03/Reduce-and-refuse-recycle-and-replace.-A-Plastics-Roadmap-for-Finland.pdf

Myhre et. al 2021. Analyse marint restråstoff 2020-2022. Tilgjengelighet og anvendelse av marint restråstoff i fra norsk fiskeri- og havbruksnćring. Report number: 2021:00633. Trondheim: SINTEF Ocean Rapport, in Rudovica V. 2021. Valorization of Marine Waste: Use of Industrial By-Products and Beach Wrack Towards the Production of High Added-Value Products, in Front. Mar. Sci., 20 October 2021. https://www.frontiersin.org/articles/10.3389/fmars.2021.723333/full

Näiriäinen N., Soppela J. 2021. Municipal interest in organic collection areas. Master Theses. https://urn.fi/URN:NBN:fi:amk-2021060314045

Näriäinen N. 2021b. Luomukeruualueita kuntiin - Luomua metsäluonnosta-hanke https://www.metsakeskus.fi/sites/default/files/document/luomua-metsaluonnosta-luomuke-ruualueita-kuntiin-raportti.pdf

Näyhä A 2019. Transition in the Finnish forest-based sector: Company perspectives on the bioeconomy, circular economy and sustainability, in Journal of Cleaner Production Volume 209, 1 February 2019, Pages 1294-1306.

NMBU 2021. Feeding pigs yeast from trees can promote healthy gut bacteria. (Published 14.12.2021). https://www.foodsofnorway.net/news/node/44473

N2Applied 2022. Company website. https://n2applied.com/then2solution/

O-I 2022. Company website. https://www.o-i.com/sustainability/glass-recycling/

Okkonen, L., Klijberg, S. 2020. Digi2Market, T1 Creating Digital Tools and Assets, Deliverable DT 1.3.2. Green Business Model Framework.

Ogilvyspirits 2022. Company website. https://ogilvyspirits.com/ogilvy-farm/our-story

Oneplanetnetwork 2017. Ocean Forest (Published on November 10, 2017). https://www.oneplanetnetwork.org/knowledge-centre/projects/ocean-forest

Otoseeds 2022. Otoseeds facebook page. https://www.facebook.com/otoseeds/

Paptic 2022. Company website. https://paptic.com/ https://paptic.com/sustainability/

Peeltech 2022. Comapnt website. https://www.peeltech.co.uk/

Pitcairn et al. 2017. Biorefining Potential for Scotland: Mapping Bioresource Arisings Across Scotland, in Industrial Biotechnology, Vol. 13, No. 6.

Plastplan 2022. Company website. https://plastplan.is/

Pusu 2022. Company website. https://pusu.ski/en/skis/

Regjeringen 2022. Norway's strategy for developing a green, circular economy – Summary. https://www.regjeringen.no/contentassets/a116f209e493471bb26c81cf645152a3/kld_strategi_sirkularokonomi_sammendrag_eng_0507.pdf

Rosemarin et. al 2020. Circular nutrient solutions for agriculture and wastewater – a review of technologies and prac-tices, in Current Opinion in Environmental Sustainability, Volume 45, August 2020, Pages 78-91.

Rudovica V. 2021. Valorization of Marine Waste: Use of Industrial By-Products and Beach Wrack Towards the Production of High Added-Value Products, in Front. Mar. Sci., 20 October 2021. https://www.frontiersin.org/articles/10.3389/fmars.2021.723333/full

Scottish Government 2016. 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

Scottish Government 2021. Cleaning up Scotland's waters (published 29.12.2021). https://www.gov.scot/news/cleaning-up-scotlands-waters/

Sitra 2021. Honkajoki makes full use of the side streams from the meat industry: "For as long as people eat meat, the by-products must be used" (published 6.9.2021). https://www.sitra.fi/en/cases/honkajoki-makes-full-use-of-the-side-streams-from-the-meat-industry-for-as-long-as-people-eat-meat-the-by-products-must-be-used/

Sitra 2021b. Spinnova makes textile fibres from pulp: "We are the only company in the world to manufacture textile fibre without harmful chemicals" (published 7.9.2021). https://www.sitra.fi/en/cases/spinnova-makes-textile-fibres-from-pulp-we-are-the-only-company-in-the-world-to-manufacture-textile-fibre-without-harmful-chemicals/

Sitra 2021c. Soilfood processes fertilisers from industrial side streams: "Processed products turns agricultural fields into carbon sinks" (published 7.9.2021). https://www.sitra.fi/en/cases/soilfood-processes-fertilisers-from-industrial-side-streams-processed-products-turns-agricultural-fields-into-carbon-sinks/

Sitra 2021d. Woodly produces clear plastic packaging made from wood: "We make achieving sustainability goals possible for large companies" (published 6.9.2021). https://www.sitra.fi/en/cases/woodly-produces-clear-plastic-packaging-made-from-wood%e2%80%afwe-make-achieving-sustainability-goals-possible-for-large-companies/

Sitra 2021e. MM Kotkamills replaces plastics in packaging with paperboard innovation: "We are creating the future for the Finnish forest industry" (published 7.9.2021). https://www.sitra.fi/en/cases/mm-kotkamills-replaces-plastics-in-packaging-with-paperboard-innovation-we-are-creating-the-future-for-the-finnish-forest-industry/

Sitra 2021f. Material innovation developed by Paptic is used to replace plastic in packaging, "We are manufacturing a material that is as strong as plastic but as easy to recycle as paper" (Published 7.9.2021). https://www.sitra.fi/en/cases/material-innovation-developed-by-paptic-is-used-to-replace-plastic-in-packaging-we-are-manufacturing-a-material-that-is-as-strong-as-plastic-but-as-easy-to-recycle-as-paper/

Sitra 2021g. Fiksuruoka brings surplus food to people's doorsteps: "The more we grow, the more we reduce food waste" (Published 7.9.2021). https://www.sitra.fi/en/cases/fiksuruoka-brings-surplus-food-to-peoples-doorsteps-the-more-we-grow-the-more-we-reduce-food-waste/

Sitra 2022. The Critical Move – Finland's roadmap to the circular economy 2.0. https://www.sitra.fi/en/projects/critical-move-finnish-road-map-circular-economy-2-0/#goals

Sitra 2022b. A circular economy. https://www.sitra.fi/en/topics/a-circular-economy/#latest

Smartfarming 2022. Website. https://smartfarming.ie/

Spinnover 2022. Company website. https://www.spinnova.com/

Storaenso 2013. Can the Finnish forest become a center for sustainable fashion? (Published 13.3.2013). https://www.storaenso.com/en/inspiration-centre/renewable-future-blog/2017/3/finnish-forest-center-for-sustainable-fashion

Storaenso 2018. Wood-based innovations to make appearance at Independence Day Reception in Finland (Published 29.11.2018). https://www.storaenso.com/en/newsroom/regulatory-and-investor-releases/2018/11/wood-based-innovations-to-make-appearance-at-independence-day-reception-in-finland

Storaenso 2022. Company website. https://www.storaenso.com/en

Suikkanen, J., Nissinen, A 2017. Circular Economy and the Nordic Swan Ecolabel -An Analysis of Circularity in the Product-Group-Specific Environmental Criteria. https://norden.diva-portal.org/smash/get/diva2:1142769/FULLTEXT01.pdf

Sustainability leap 2022. Website. https://kestavyysloikka.ymparisto.fi/en/

Theexplorer 2020. Circular economy: Norwegian technology promotes sustainable use of natural resources (Published 15.1.2020). https://www.theexplorer.no/stories/renewable-resources/norway-sees-a-myriad-of-possibilities-for-future-resource-use/

NCP 2019. A chair made of recycled plastic (Published 15.4.2019). https://ncp.no/en/news/en-stol-laget-av-resirkulert-plas/

Theexplorer 2022. Green and sustainable solutions from Norway, N2 Applied reduces emissions from food production and turns organic waste into an effective fertiliser. https://www.theexplorer.no/solutions/n2-applied-reduces-emissions-from-food-production-and-turns-organic-waste-into-an-effective-fertiliser/

Theexplorer 2022b. Green and sustainable solutions from Norway, Oil and protein from residual raw material from fish. https://www.theexplorer.no/solutions/oil-and-protein-from-residual-raw-material-from-fish/

Theexplorer 2022c. TotalCtrl Restaurant helps restaurants to reduce food waste. https://www.theexplorer.no/solutions/totalctrl-restaurant-helps-restaurants-to-reduce-food-waste/

Theexplorer 2022d. New and safe active ingredient for plant protection. https://www.theexplorer.no/solutions/new-and-safe-active-ingredient-for-plant-protection/

Theexplorer 2022e. From plastic waste to design furniture that lasts a lifetime (Published 18.2.2020). https://www.theexplorer.no/stories/ocean/from-plastic-waste-to-design-furniture-that-lasts-a-lifetime/

Theexplorer 2022f. Website. https://www.theexplorer.no/

The Ministry of Agriculture and Forestry 2022. The circular economy is an opportunity for Finland. https://mmm.fi/en/circular-economy

The Irish Times 2021. Microplastics found in 90% of protected Irish marine environments – study. https://www.irishtimes.com/news/environment/microplastics-found-in-90-of-protected-irish-marine-environments-study-1.4649484

Vegware 2022. Company website. http://www.vegware.com/uk-en/page/our-team/

Waister 2022. Company website. http://waister.eu/about-us/

Wolfslehner et. al 2020. European forest governance post-2020.

WRS 2022. Wester Ross. https://www.wrs.co.uk/environment

Yara 2022. Company website. https://www.yara.fi/uutiset-ja-tapahtumat/uutiset/2021/ecolan-oyn-nimi-muuttuu-yara-eco-oyksi/

Zerowaste 2022. Lisäarvoa tuottava ZeroWaste Ympäristö-raportointi. https://www.enpros.fi/ratkaisumme/ymparistoraportointi/

Zero Waste Scotland 2015. Sector Study on Beer, Whisky and Fish, Final Report, Harwell, Ricardo-AEA Ltd.

Zero Waste Scotland 2022. Waste (Scotland) Regulations.
https://www.zerowastescotland.org.uk/content/waste-scotland-regulations-faqs

Zero waste Scotland 2022b. Scottish businesses leading the way.
https://www.zerowastescotland.org.uk/circular-economy/in-action

Zero waste Scotland 2022c. Waste (Scotland) Regulations - Case Studies.
https://www.zerowastescotland.org.uk/content/waste-scotland-regulations-case-studies

Zero Waste Scotland 2022d. Website. https://www.zerowastescotland.org.uk/