



CIRCULÉIRE'S CIRCULAR SECTORAL GUIDES

Unpacking the circular innovation
opportunities for Ireland's Fashion
and Textiles Sector



An Roinn Comhshaoil,
Aeráide agus Cumarsáide
Department of the Environment,
Climate and Communications



Authorship

Authors of CIRCULÉIRE's Circular Fashion and Textiles Sectoral Guide are:

© 2022 Irish Manufacturing Research

Suggested citation: *Irish Manufacturing Research (2022). CIRCULÉIRE Sectoral Guide – Unpacking the circular innovation opportunities for Ireland's Textile & Fashion Sector.*

About CIRCULÉIRE

CIRCULÉIRE, the National Platform for Circular Manufacturing seeks to accelerate Ireland's transition towards a net-zero carbon circular economy. A key objective of the programme is to demystify, de-risk and deliver circular business model innovation for Irish industry.

Want to learn more about CIRCULÉIRE? Visit our website at www.circuleire.ie or contact circuleire@imr.ie

Contents

Acronyms	5
Executive Summary	6
Strategic importance of Ireland’s Fashion and Textiles Sector to our climate and sustainability targets.....	6
A case study-led approach to building the case for Circular Fashion and Textiles	7
Key Findings & Key Enablers of Circular Fashion and Textiles.....	10
Key Barriers to a Circular Fashion and Textiles Sector	11
Five key recommendations to unlock the circular potential of Ireland’s Fashion and Textiles sector	13
Where next for Circular Fashion and Textiles in Ireland?	15
Section 1: The Fashion & Textile Sector in Ireland	16
Ireland’s Fashion and Textiles Sector	16
Impact of the Fashion and Textiles sector in Europe	17
What Do We Mean by Circular Fashion and Textiles?	18
Benefits of Circularising Ireland’s the Fashion and Textiles Sector.....	21
Key Stakeholders.....	22
Policy Drivers and Government Support.....	23
Purpose of this Guide	27
Methods.....	28
Structure of the Guide.....	29
Section 2: Circular Innovations in the Fashion & Textile Sector	30
Cluster 1: Circular Materials, Resources and Inputs.....	34
Cluster 2: Circular Manufacturing Processes.....	40
Cluster 3: Circular Business Models in Textile and Fashion Industry	45
Cluster 4: End of Use Circular Strategies	51
Section 3 - What's Needed to Circularise Ireland’s Fashion and Textiles Sector? ...	56
Key Enablers/Lessons Learnt from the Case Studies and Wider Literature.....	56
Key Barriers in transitioning to a Circular Economy.....	59
Building an Environment for Circular Economy in Ireland’s Fashion and Textiles Sector.....	62
Five Key Recommendations to Advance Ireland's Circular Fashion and Textiles Sector.....	63
a. Initiate Education and Awareness Campaigns About How to Reduce Over-Consumption and Prevent Post-Consumer Textile Waste	63
b. Cross-Sectoral Collaboration for Circular Economy	64

c. Implement Policy Innovations that align with the goal of circularizing the Fashion and Textiles Sector.....	65
d. Ensuring Funding and Investment is Directed Strategically Towards Building an Ecosystem that Facilitates Circular Fashion and Textiles.....	66
e. Develop Key Players' Competencies and Skills	67
Resources and Tools.....	68
References	69

Acronyms

- CRNI** - Community Reuse Network Ireland
- CEAP** - European Circular Economy Action Plan, 2021-2027
- DCCI** - Design & Crafts Council of Ireland
- DECC** - Department of Environment, Climate and Communications
- ECESP** - European Circular Economy Stakeholder Platform
- EMF** - Ellen MacArthur Foundation
- EPA** – Environmental Protection Agency (Strategic Partner - CIRCULÉIRE')
- ESPR** - Eco-design for Sustainable Products Regulation
- EURATEX** – The European Apparel and Textile Confederation
- FSC** - Forest Stewardship Council
- ICSA** - Irish Charity Shop Association
- IMR** – Irish Manufacturing Research (Secretariat – CIRCULÉIRE)
- JRC** – European Joint Research Centre
- LCA** – Lifecycle Analysis
- LSJH** - Lounais-Suomen Jätehuolto
- Meda** - Metropolitan Economic Development Association (Minnesota)
- Resortecs** – REcycling, SORTing, TEChnologieS
- SDGs** - United Nations Sustainable Development Goals
- SPI** - Sustainable Products Initiative
- UNEP** - United Nations Environment Programme
- UNIDO** - United Nations Industrial Development Organization
- WAPCE** – Waste Action Plan for a Circular Economy
- WBCSD** - World Business Council for Sustainable Development
- WFD** - European Waste Framework Directive

Executive Summary

CIRCULÉIRE's Fashion and Textiles Good Practice Sectoral Guide is intended for those involved in the apparel and textiles industry, including economic operators in the value chain – such as retailers - and policy makers. It aims to provide industry stakeholders with an overview of industry-led circular innovations that are shaping the fashion and textiles sector domestically and in other parts of the world, and to highlight the opportunities to circularise textiles value chains here in Ireland. It is part of a series of reports produced by Ireland's National Platform for Circular Manufacturing targeted at Irish industry players in sectors deemed strategically important to supporting Ireland's transition to a circular economy.

Strategic importance of Ireland's Fashion and Textiles Sector to our climate and sustainability targets

Tangible socio-economic benefits are expected for those countries willing to invest in the infrastructure and technologies needed to support the development of a circular fashion and textiles sector domestically. Research undertaken in Finland¹ – a country with a comparable GDP and population to Ireland, has projected that transitioning to a circular economy is expected to create at least €1.5 – 2.5 billion growth potential per year for the Finnish economy (Kämäräinen, 2020). Meanwhile, by 2025, while it is estimated that Finland's domestic textile ecosystem could create as many as 17,000 new jobs in the country (Lounais-Suomen Jätehuolto, 2022). Further, a circular economy supports the investment in infrastructure and better facilities to support the growing economy (DECC, 2019). The Whole of Government Strategy for a Circular Economy, for instance, acknowledges that the use of textile waste as a secondary raw material can provide opportunities for new domestic manufacturing (Government of Ireland, 2021).

Even more urgently, the textile industry is often described as one of the most polluting and resource-intensive industries in the world. It represents significant environmental and climate pressures in every phase of its lifecycle from the production of fibres and textile products to distribution and retail, use of textiles, collection, sorting and recycling, and final waste management. These pressures include using virgin resources, greenhouse gas emissions, and chemicals/water pollution. Ireland presently ranks second last across the EU-27 in terms of our material reuse rates. Transitioning to a Circular Fashion and Textiles sector will be critical to future-proofing Ireland's economy against linear risks (such as the sector's resource intensiveness; reliance on toxic and non-renewable resources; and prioritisation of sales of virgin products), whilst making progress against our sustainability and climate commitments. The currently linear Textiles value chain places untold pressures on resources, environment, social impacts including:

¹ Finland is highlighted a national frontrunner in advancing a national ecosystem for Circular Fashion and Textiles. For more see the mini case study in Section 3 of this Guide.

Across all EU Member States, supply chain pressures from clothing, footwear, and households, textiles represent:

- The fourth highest impact on the environment and climate change, after food, housing and mobility (EC, 2022). The production of clothing, footwear and household textiles for Europeans contributed to an estimated 654 kg of CO₂ equivalent emissions per EU capita in 2019 (EEA, 2020). Most of these emissions were generated outside of the EU.
- The fourth highest pressure on primary raw materials (15%) after food, housing, and transport. In 2017 alone, it resulted in an estimated 1.3 tonnes of primary raw materials per person (Christis et al., 2019) the fourth highest pressure category for water use. In this same period (2017), textiles consumption in these categories resulted in 104 m³ of water being used

Meanwhile, nationally textiles are a major contributor to Ireland's national waste stream. Research commissioned by the EPA has found that:

- Per capita generation of post-consumer textiles waste (clothing, footwear and other textile products) in Ireland is estimated at 35 kg per person per year, around 170,000 tonnes per year. This is higher than the reported EU average of 26 kg per person per year (O'Leary et al., 2021);
- Household bins are identified as the single largest source of post-consumer textiles waste, with circa 64,000 tonnes of clothes and other textiles being disposed as household waste via kerbside collection annually - 42,000 tonnes of which are comprised of clothing (*Ibid*)

A case study-led approach to building the case for Circular Fashion and Textiles

"Textiles are products of clothing, footwear and interior furnishings (e.g. carpets, curtains, bedding, furniture) composed of at least 80% by weight of textile fibres (based on EU textile labelling regulation 2011)." – WAPCE, 2019

A circular fashion and textiles economy is defined as a regenerative system in which garments or textiles are circulated for as long as their maximum value is retained, and then returned safely to the biosphere when they are no longer of use (EMF, 2017a). Ellen MacArthur Foundation (2017a) examines the vision for a new textiles economy through three focus areas that are critical to realising this vision:

1. New business models that increase use of clothing items,
2. Safe and renewable inputs, and
3. Solutions so used clothes (and textile products) are turned into new

In such a framework, fashion and textile products are designed with resource efficiency, non-toxicity, biodegradability, and recyclability and reuse in mind. They would be sourced and produced with priority given to recyclable sources and ethical practices. Efforts should also be made to shift from virgin to secondary raw

materials, and to design out materials that are unsuitable for reuse or recycling, shifting to renewable, biodegradable materials that can be used as compost for plants and other organisms in the ecosystem when they can no longer be used (Hetherington et al., 2020).

The Guide adopts a case study-led approach to building the case for Circular Fashion and Textiles Sector in Ireland. It profiles 12 circular innovations which range in maturity and technological readiness level from earlier-stage solutions which are just starting to enter the market (with TRL 7 or 8), such as the Mi Terro, Resortecs and RESYNTEX examples, and more mature, market-ready and fully commercialised circular innovations, such as Nudie Jeans Co. and Renewal Workshop (TRL 9). These examples have been purposefully selected on the basis that they illustrate the considerations of initiating and scaling circular fashion and textile innovations at different stages of maturity. Long-established circular businesses (like Nudie Jeans Co.), illustrate that while the economic, environmental and social impact rewards for circular businesses can be great - the task of becoming more circular is never over.

The case studies profiled below are categorised according to the following priority clusters which illustrate the circular innovation opportunities at priority points of the textiles lifecycle: 1) **Circular Materials, Resources and Inputs**; 2) **Circular Manufacturing Processes**; 3) Circular Business Models, and 4) **End-of-Use Circular Strategies**.

Table 1.1 Overview of the case studies

Cluster	Case study name (include project/website links)	Region covered	What are the top CE Strategies?	What is the TRL of the initiative?
Circular materials, resources and inputs	Mi Terro upcycling agricultural waste into biomaterials for the fashion industry	Production facilities in California, USA	Valorisation of organic waste material	TRL 7
	Spinnova developed textile fibres from renewable wood raw material (pulp)	Helsinki, Finland	Novel (biobased / biodegradable) material	TRL 8
	Teemill sets a traceable supply chain within T-shirts production	United Kingdom	Circular supply chain and traceable materials	TRL 9

Cluster	Case study name (include project/website links)	Region covered	What are the top CE Strategies?	What is the TRL of the initiative?
Circular manufacturing process	Resortecs has adopted a 'design for disassembly' approach to produce thermally dissolvable thread for clothing	Ghent, Belgium	Design for disassembly	TRL 8
	DyeCoo commercial water-free and process-chemical free-dyeing technology for textiles processes	Netherlands	Resource efficiency	TRL 9
	Infinna™ - using cellulose carbamate processes to produce a cotton-like and sustainable fibre out of post-consumer textile waste	Finland	Lean manufacturing	TRL 9
Circular business models	DressX provides a solution for social media content creation without the need for physical products.	USA	Digitization and virtualization; Resource Efficiency	TRL 8
	thredUP has initiated a buy back scheme for old clothes from any brand in US	USA	Buy Back scheme; Reverse Logistics	TRL 9
	Circos has introduced a subscription model for baby clothing where members pay a monthly	Netherlands; Europe	Product service system (PSS)	TRL 9

Cluster	Case study name (include project/website links)	Region covered	What are the top CE Strategies?	What is the TRL of the initiative?
	Nudie Jeans Co Reuse and Repair programmes keep existing jeans in use for longer	Sweden; Worldwide	Take back scheme; Reuse; Repair	TRL9
End of use circular strategies	Renewal Workshop capturing value from unsellable inventory through renewing and upcycling products	Oregon, USA	Refurbishment	TRL 9
	RESYNTEX using chemical recycling to recover secondary raw materials from unwearable textile waste	Slovenia, Belgium, Germany, France, UK	Depolymerization; Industrial Symbiosis	TRL 7

Key Findings & Key Enablers of Circular Fashion and Textiles

Our research finds that while there is top-level support for sustainable, circular fashion to develop in Ireland, to date, most circular fashion and textiles activity operates in the social rather than commercial sectors and is predominantly focused on reuse and recycling of post-consumer waste – rather than at the earlier design phases of textile and apparel production. Based on the availability of agricultural and bio waste in Ireland, our research suggests there are considerable opportunities to replicate and advance circular bioeconomy innovations to produce sustainable bio-materials for the textiles sector (like the Mi Terro and Spinnova case studies profiled in this Guide). If developed in an environmentally considered way, these biodegradable, renewable and circular fibres have the potential to support the circular transition of the sector whilst increasing the resource efficiency and sustainability of the agriculture and forestry sectors in the country.

Summary: Key Enablers and Lessons Learnt from the Case Studies	
Start with small but measurable changes	A critical first step to embarking on your business's transition to a circular economy is to identify small but measurable changes where your company can concentrate its efforts. The Resources and Tools section of this Guide includes helpful resources to get you started.
Adopt a culture of iterative Research and	A success factor for many of the circular fashion and textiles companies profiled for this guide is that they have embedded a culture of sustained research and development around

Summary: Key Enablers and Lessons Learnt from the Case Studies	
<i>Innovation in the company</i>	circular innovations. Research partnerships - such as through innovation vouchers and grant funding - with academic institutions and RPOs can assist in initiating research-led innovations.
<i>Find appropriate Financing and Support to initiate your business's Circular textile and fashion innovation project(s)</i>	Where support is being sought, consider the Technology Readiness Level (TRL) of your project. The maturity of the solution, and proximity to market is likely to have a bearing on where appropriate financing and support can be accessed. A growing number of financial supports and initiatives can be accessed by established fashion and textiles SMEs and enterprises to support them on their circular economy journeys (outlined more fully in Section 3 of this Guide).
<i>Circular fashion and apparel businesses must re-think traditional customer relationships</i>	Circular companies are rethinking how they interact with their customers, promoting a more collaborative, eco-conscious relationship than traditional linear businesses. Such businesses are taking greater responsibility for the products (and waste) they put on the market and are looking at how they can extend their products' lifespans through repairs and re-selling. Rethinking an apparel companies' relationship to customers, such as by shifting to a Product-as-a-Service model, unlocks new opportunities for circular business model innovations.
<i>Recognise the increasingly important role of technology and digitalisation:</i>	Technology and digitalisation will play an increasingly important role in facilitating collaboration, and data gathering and sharing between value chain stakeholders around circular supply chains, product traceability and circularity performance. A digital product passport for textiles ² is expected to be introduced based on mandatory information requirements on circularity and other key environmental aspects.

Key Barriers to a Circular Fashion and Textiles Sector

From the wider literature and case studies, several common barriers to transitioning to a circular fashion and textiles ecosystem have been identified. These include:

Summary: Key Barriers to Fashion and Textiles Sectoral Transformation	
<i>Ireland is at the end of a long global distribution chain</i>	Ireland today is a net importer of clothing and textiles, much of which today is cheaper, fast-fashion garments. This reality that Ireland is at the end of a long global distribution chain must be front and centre when looking at how the sector can be circularised now and in the future. It suggests that second-life enablers, and fashion and apparel retailers will need to

² Linked to the SPI and EU Strategy for Sustainable and Circular Textiles.

Summary: Key Barriers to Fashion and Textiles Sectoral Transformation	
	play an important role, particularly in exploring opportunities to valorise post-consumer textile waste at scale.
<i>Insufficient incentives for value chain collaboration and pre-competitive action between actors.</i>	Transitioning towards circular value cycles and business models across the value chain requires a pre-competitive space where different fashion and textiles ecosystem stakeholders can collaborate and test new models (Global Fashion Agenda, 2021). Presently, there are insufficient incentives for value chain collaboration between actors. Other barriers to circular economy are found in relation to the role individual companies play in a value chain as well as to the dominating logic of how they sell and distribute their goods to the market (Ritzén and Sandström, 2017). Standardized consumer labelling, infrastructure for collection and sorting, and shared logistics are all needed (Global Fashion Agenda, 2021).
<i>Circular Fashion and Textile businesses will remain niche in a linear economy</i>	The market for circular fashion and textiles businesses is currently limited to a market niche populated by environmentally and socially conscious consumers and social actors committed to sustainable consumption (JRC, 2021). A study by the JRC suggests that as long as the economic framework favours a linear growth model, “circular enterprises are restrained from gaining traction in the textile market” (<i>Ibid.</i>). Circular businesses are outcompeted by linear businesses where, environmental and social costs are usually externalised – this allowing for low-cost and short-lived clothing to be offered on the mass market.
<i>Overconsumption remains a barrier to circular fashion and textiles</i>	Overconsumption remains an intractable barrier. Per capita consumption of new textiles in Ireland was estimated at 53 kg per person in 2019 - an amount which increased from the previous year (EPA, 2021). Missing knowledge and poor confidence in the environmental claims of recycling strategies and materials (e.g. use of mono-fibres versus mixed fibres) and queries about the high cost and perceived lower quality are also barriers for customers to adopt more circular consumption practices (BMZ, 2017; JRC, 2021). While there are insufficient incentives to change consumption habits and promote concepts of sharing, leasing, re-using or wearing garments for a longer period.
<i>Externalisation of costs, underdeveloped infrastructure for separate collection and</i>	Macro-economic barriers that inhibit the adoption of circularity in the textile industry. Compared to the price of recycled fibres, the market price for virgin textile fibres is low (Elander & Ljungkvist, 2016). This can be attributed to the lack of internalisation of external costs of virgin fibre production – despite the wide range of environmental benefits that

Summary: Key Barriers to Fashion and Textiles Sectoral Transformation

<p>recycling, textile exports and lack of funding</p>	<p>renewal, reuse and recycling activities can achieve. A lack of infrastructure for collecting, sorting and recycling post-consumer textiles waste and recycling, and competitive markets hinder a rapid transformation of the sector. Consequently, separation of mixed fibres is deemed too costly and recycling technologies are not (yet) producing textiles of equivalent quality and performance at scale.</p>
<p>Insufficient Data and failure to integrate Circular Design principles into production processes contributes to poor circularity outcomes</p>	<p>Fast fashion consumption has resulted in ever-higher quantities of low-quality textile waste, making it unfeasible to recycle or resell at an economic margin (Koszewska, 2018). Decisions made during the design stage of apparel influence the circular economy model to a greater extent (Earley, 2020). Based on the design of the product, specifications like colour, material usage, manufacturing method, and finishing all have a bearing on the recyclability of the product at end-of-use. A lack of data and lack of reporting requirement on the circularity status and treatment of post-consumer textiles and on the overall fibre composition of non-reusable textile waste is inhibiting the ability to set policy targets and measures to increase circularity (JRC, 2021). This contributes to limited planning reliability for investments in textile recycling and technological innovation (<i>Ibid.</i>).</p>

Five key recommendations to unlock the circular potential of Ireland’s Fashion and Textiles sector

<p>Key Recommendations: Unlocking Ireland’s Circular Fashion & Textiles Potential</p>	
<p>Initiate Education and Awareness Campaigns About How to Reduce Over-Consumption and Prevent Post-Consumer Textile Waste</p>	<p>As is noted in the WAPCE, our research underscores the need for Government to launch an education and awareness campaign around textiles as a theme of SDG 12 Sustainable Production and Consumption (DECC, 2020). Any campaigns must take prevention as their starting point, and recognise that less consumption of clothing, and care and repair of clothing will be critical to stemming the current challenges of a linear (and fast) fashion and textiles economy. Meanwhile alternative circular business models should be promoted and supported – exploring how clothes swap and rental services, such as the Nu Wardrobe (IE) or Uniform Reuse (UK) or fashion libraries found elsewhere – like NYPL (US) or LENA (NL), can be more easily accessed. Industry representatives must be engaged with to standardise and implement consumer-facing eco-labels, such as Nordic Swan, which building consumer trust in textile products’ circular and environmental credentials.</p>

Key Recommendations: Unlocking Ireland's Circular Fashion & Textiles Potential

<p>Cross-Sectoral Collaboration for Circular Economy</p>	<p>Collaboration and coordination between key parts of the textiles value chain is key. The government can also play a critical role as convener and innovation broker in support of this goal of joining up the value chain, adopting an inclusive, multistakeholder model:</p> <ul style="list-style-type: none"> • Engage with key operators across the textiles value chain to co-design transition pathways and deep demonstrators to achieve a net-zero carbon circular economy for the island of Ireland. Providing best-in-class thought leadership and guidance to industry about best practices, to assess transition infrastructure needs and barriers, and to co-define high priority deep demonstrator pilots with potential to advance a circular fashion and textile sector for Ireland. • Highlight forthcoming circular economy policy and regulatory changes to industry in a timely manner linked to the industry's Transition Agenda, ensuring that feedback to ensure the successful adoption of such policy changes is done in a timely and inclusive manner. • Share circular innovation success stories.
<p>Implement Policy Innovations that align with the goal of circularizing the Fashion and Textiles Sector.</p>	<p>International precedents demonstrate how Government can implement different policy and legislative levers to stimulate circular fashion and textiles both upstream and downstream. France implemented a law in 2019 banning the destruction of unsold clothing (which the forthcoming Sustainable Products Initiative looks set to implement across Europe). Sweden has instituted reduced VAT on repair activities undertaken on household items like clothing. Meanwhile, higher tax rates could also be levied on less sustainable and circular fashion products (Mizrachi and Tal, 2022), to increase first mover and competitive advantages for fashion firms that actively working to be more circular and sustainable. Such efforts would support the objectives of the WAPCE by reducing the cost differential of higher value indigenous producers.</p>
<p>Ensuring Funding and Investment is directed strategically towards building an Ecosystem that advances</p>	<p>While a steady number of grant funding, and financial and non-financial support instruments are coming on stream, there is a risk that without a strategic and cross-cutting funding and investment agenda to frame the sector's current and future transition investment needs, funded projects may be ad hoc and piecemeal. Recent development, like Slovenia's national Financing the Circular Transition programme, illustrates the value of looking to align grant funding</p>

Key Recommendations: Unlocking Ireland's Circular Fashion & Textiles Potential

Circular Fashion and Textiles

architecture and investment capital around identified strategic transition goals that require financing, such as large-scale infrastructure investments.

Moreover, there is a need to create funding and supports that in addition to supporting individual companies look to strategically address systemic gaps or market failures in the current linear system. Related to this point, the role that Business Finland has played in being a “investor of first resort” (Mazzucato, 2011) in developing the country’s national textiles recycling infrastructure offers an interesting precedent that could be emulated in the Irish context, should the need and feasibility of doing so be established.

Where next for Circular Fashion and Textiles in Ireland?

By continuing to develop a better understanding of the scale and diversity of circular fashion and textiles innovations already underway, both in Ireland and elsewhere in Europe, we can continue to raise the ambition of Ireland’s fashion and textiles sector in working towards a transition to a net-zero circular economy. In this way, the learnings and insights highlighted by the industry and regional case studies in this Sectoral Guide are intended to provide encouragement and give confidence to potential first movers who might build upon them and undertake circular fashion and textiles innovations. Moreover, it is the authors’ hope that the key findings and recommendations put forward in this Guide will feed into government circular economy strategy activities, such as the Textiles Sectoral Roadmap, highlight potential ways forward for value chain stakeholders.

Section 1: The Fashion & Textile Sector in Ireland

Textiles and clothing are a fundamental part of everyday life and an important sector both in Ireland and the global economy. Every year in Ireland, thousands of tonnes of textile-based products are purchased, used, and thrown away. The proliferation of production and consumption of textiles has given rise to significant environmental and climate impacts ([EPA, 2021](#)). The unsustainability of the fashion and textiles industry is particularly exasperated in the currently 'take-make-dispose' linear economic model. Section One of this Guide will briefly describe the state of play of the Irish fashion and textiles sector and will provide a high-level overview of some of the key policies and initiatives that are driving circular economy in this sector both in Ireland and Europe.

Ireland's Fashion and Textiles Sector

Textiles products cover clothing, footwear, and interior furnishings (e.g., carpets, curtains, bedding, furniture) that are comprised of at least 80% by the weight of textile fibres (European Parliament, 2011).

The production of textiles has one of the most complex global value chains, involving millions of producers and billions of consumers worldwide. Since 1975, the global production of textile fibres has almost tripled, and over the past decade, clothing prices have fallen relative to inflation. This issue is particularly pronounced in the apparel industry, where lower prices, compressed production cycles and greater variety and availability of clothing have resulted in consumers buying many more items of clothing, a phenomenon known as 'fast fashion' (DECC, 2019). Meanwhile the average number of clothing collections by European apparel companies has more than doubled, from two a year in 2000 to about five a year in 2011 (McKinsey, 2016).

While Ireland once had a thriving indigenous textiles industry, particularly for linen and wool, since the late 1990s, Ireland has experienced a pattern of decline in these sectors. The movement of manufacturing facilities to developing and emerging economies resulted in several high profile closures of plants and job losses occurred in textile and clothing manufacturing (Keane and te Velde, 2008). Today, the sector depends on balancing imports and exports trading off skills and knowledge for production, with Ireland importing 162,000 tonnes of new textiles, clothing, and footwear each year (EURATEX, 2015). This is worth over €2.04 billion per annum and represents per capita textiles consumption of 54 kg (i.e., imports plus production minus exports for the country), equivalent to €500 per Capita (EURATEX, 2015).

Profile of the sector today

A range of commercial operators and manufacturers actively produce clothing and garments in Ireland today. CSO data from the PRODCOM survey finds that Ireland's textile manufacturing was worth 375 million Euro in the 2019 period ([CSO, 2019](#)). Of this amount, the two largest textile manufacturing sectors in terms of value are

non-clothing, with non-clothing finished products (linen, curtains, blankets, etc.) valued at just over €100 million and woven fabrics at just under €100 million ([EPA, 2021](#)). Commercially, the largest operators include Aran Woollen Mills Unlimited Company, the LCC Clothing (Ireland) Ltd., Blarney Woollen Mills Group Ltd, Deer Park Knitwear Ltd, and Bensons Workwear Ltd. with market values aligned as mentioned from highest to lowest (ibisworld, 2021). Much of the focus of circular fashion and textiles activity has focused on valorising post-consumer textile waste – rather than upstream industry activity.

Impact of the Fashion and Textiles sector in Europe

In recent years, demand for textile fibres, first and foremost in the fast fashion segment, has increased tremendously due to its low price. Meanwhile, a decline in the quality of textiles has meant that it has little resale value and ends up dumped in landfill (RTÉ, 2021). Global fibre consumption is expected to reach between 130 and 145 million metric tonnes by 2025 (EMF, 2019). At the same time, the textile industry is often described as one of the most polluting and resource-intensive industries in the world. It represents significant environmental and climate pressures in every phase of its lifecycle from the production of fibres and textile products to distribution and retail, use of textiles, collection, sorting and recycling, and final waste management. These pressures include using virgin resources, greenhouse gas emissions, and chemicals/water pollution.

Across all EU Member States, supply chain pressures from clothing, footwear, and household textiles represents:

- (i) the fourth highest pressure on primary raw materials (15%) after food, housing, and transport. In 2017 alone, it resulted in an estimated 1.3 tonnes of primary raw materials per person (Christis et al., 2019) the fourth highest pressure category for water use. In this same period (2017), textiles consumption in these categories resulted in 104 m³ of water being used
- (ii) the production of clothing, footwear and household textiles for Europeans contributed to an estimated 654 kg of CO₂ equivalent emissions per EU capita, making textiles the fifth largest source of CO₂ emissions linked to private consumption in 2019 (EEA, 2020). Most of these emissions were generated outside of the EU.

Moreover, the textile production processes use a large amount and variety of chemicals, dyes, and other harmful toxins, which pose health risks to the textile workers, and the local communities and environments directly exposed to these substances. Approximately 3500 substances are used in textile production. 750 have been classified as hazardous for human health, and 440 as hazardous for the environment. It is estimated that about 20% of global water pollution is caused by dyeing and finishing textile products, which contaminates the water supply of workers and local communities (EEA, 2020). At the post-production stage, the washing of textiles releases additional chemicals and microplastics into household wastewater. It is estimated that about half a million tonnes of plastic microfibres

are released into the ocean annually from washing plastic-based textiles (UNEP, 2020).

The Rana Plaza disaster, where 1,138 garment workers died when a factory in Bangladesh collapsed in 2015 was viewed by many as a watershed moment for Europe's Fashion and Textiles Sector. It underscored the need for greater safety, fairness, transparency, and oversight in the textile industry's supply chain relations and working conditions, particularly for suppliers and manufacturers operating outside of the EU. As a net importer of fashion and textile products and materials, it is not only the embodied emissions associated with transportation, but also the socio-economic and environmental impacts of international textiles trade that must be considered when looking to make Ireland's fashion and textiles sector more circular and sustainable.

What Do We Mean by Circular Fashion and Textiles?

A circular fashion and textiles economy is defined as a regenerative system in which garments or textiles are circulated for as long as their maximum value is retained, and then returned safely to the biosphere when they are no longer of use (EMF, 2017a). Ellen MacArthur Foundation (2017a) examines the vision for a new textiles economy through three focus areas that are critical to realising this vision:

- (i) New business models that increase use of clothing items,
- (ii) Safe and renewable inputs, and
- (iii) Solutions so used clothes (and textile products) are turned into new

In such a framework, fashion and textile products are designed with resource efficiency, non-toxicity, biodegradability, and recyclability and reuse in mind. They would be sourced and produced with priority given to recyclable sources and ethical practices. Efforts should also be made to shift from virgin to secondary raw materials, and to design out materials are unsuitable for reuse or recycling, shifting to renewable, biodegradable materials that can be used as compost for plants and other organisms in the ecosystem when they can no longer be used (Hetherington et al., 2020).

Given the challenges associated with Ireland's currently linear 'take-make-waste' model of clothing consumption, there is a clear social, economic and environmental imperative to advancing a circular fashion and textiles economy for Ireland. This economic paradigm would centre on phasing out the root causes of waste and pollution by design, keeping existing products and materials in productive use, regenerating natural systems and supporting the wider goals of Ireland's 2030 Sustainable Development Agenda. In addition, a circular textile economy presents an economic opportunity that ensure Ireland's textile production and consumption is brought closer to a zero-carbon circular economy, whilst creating sustainable employment opportunities.

Circular challenges facing the sector

While total estimates about the impacts of Ireland's wider fashion and textiles sector have not yet been determined (and warrants further investigation), the consumption of new textiles in the Irish context has been the subject of research commissioned by the Environmental Protection Agency (EPA, 2021). This study, and data from key sources such as the Central Statistics Office (CSO), has determined that:

- Per capita generation of post-consumer textiles waste (clothing, footwear and other textile products) in Ireland is estimated at 35 kg per person per year, around 170,000 tonnes per year. This is higher than the reported EU average of 26 kg per person per year.
- Household bins are identified as the single largest source of post-consumer textiles waste, with circa 64,000 tonnes of clothes and other textiles being disposed as household waste via kerbside collection annually - 42,000 tonnes of which are comprised of clothing.
- 40,000 tonnes of post-consumer textiles are collected annually by commercial textile recyclers via their textile banks and through community and club collections
- Each year, the Irish charity sector collects an estimated 17,500 tonnes of post-consumer textiles, of which around 8,500 tonnes are sold in the charity shops and approximately 9,000 tonnes are sold to the commercial textile recyclers for export overseas or recycling.
- An estimated 18,000 tonnes of post-consumer textiles from the non-domestic sector annually, i.e. commercial and industrial facilities via kerbside waste collections.
- Other sources of post-consumer textiles include textile packaging waste, vintage and online sales, textile industry sector, litter etc. (O'Leary et al., 2021).

While public awareness of sustainable fashion consumption and production has expanded in recent years, overconsumption remains a major challenge. Ireland is the home to Primark, one of largest fast fashion companies worldwide, with an annual revenue of circa €6.55 billion (FUG, 2022). EC research supports this idea that Ireland is starting to take action to increase awareness of and address climate change and pollution. Furthermore, Irish designers and start-up fashion brands are starting to adopt sustainability practices, recognising the circular economy as an opportunity to expand their business (Centre for Sustainable Fashion, 2019).

While all this suggests there is top-level support for sustainable, circular fashion to develop in Ireland, to date, most circular fashion and textiles activity operates in the social rather than commercial sectors and is predominantly focused on reuse and recycling of post-consumer waste – rather than at the earlier design phases of textile and apparel production. As of yet, the circular fashion and textiles market remains in its infancy amongst commercial operators, with limited industry-led circular fashion and textile activity in Ireland. Reuse is promoted as a preferable intervention before recycling, and is associated with reduced cost for collection, segregation and limitations to recycling processes. The Irish Charity Shop

Association (ICSA) members collaborate with retailers to sell used clothing (Connolly et al., 2017). A number of small-scale circular fashion industry operators have entered the market in recent years, such as NU Wardrobe which provides a platform for peer-to-peer clothes swapping in Ireland (NU Wardrobe, 2022) and the Thriftify (<https://www.thriftify.ie/>) – an e-commerce platform that connects 98% of Ireland's charity shops with end-consumers ([TechCentral, 2021](#)).

The Rediscover Fashion hub in the Rediscovery Centre Dublin, the National Centre for the Circular Economy, provides resources, skills and training to upcycle clothing and also works with other sectors such as furniture. The scheme is expected to expand to support SMEs and mentor start-ups (Dept. of Communications Climate Action and Environment, 2019). Meanwhile, luxury fashion store, Brown Thomas, is collaborating with 'The Restory', a London-based repair specialist, by offering customers a drop-off repair service that aims to extend the lifespan of their luxury items ([Brown Thomas, 2022](#)).

Other Irish Circular Fashion and Textiles Industry players and Initiatives:

- [Mamukko](#) promotes upcycling by using end-of-life sails, decommissioned life rafts and recycled leather to make bags.
- [The Upcycle Movement](#) upcycles discarded objects or materials in such a way to create new product such as bags.
- [CRANN](#) produces sunglasses and watches from sustainable recycled raw materials, thereby displacing plastic.
- CIRCULÉIRE Industry Member, [Cirtex Ltd.](#), is a new circular textiles venture which upcycles textiles to produce a [wide range of valuable products](#), including [thermal and acoustic insulation](#) for domestic and commercial use, [floor underlay](#), [arena fibre](#), and [insulator pads for mattresses and furniture cushioning](#). In 2022, Cirtex (in partnership with [Interior Creations Ltd](#), [Longford County Council](#), and [Clare County Council](#)) received innovation pilot funding from CIRCULÉIRE to pilot a collection scheme to recover the tonnes of mattresses, pillows, duvets, furniture, and post-production waste like off-cuts end up being incinerated as Ireland has no answer to upcycling this end-of-life material. The demo project aims to show that these materials can be collected from the public in a clean and effective manner.
- [Attention Attire](#) - *Community Reuse Network Ireland* create limited edition, handmade outerwear and accessories from upcycled camping gear left behind at Ireland's music festivals.
- [CRNI's Circular Textiles project](#) is a pilot programme to test the impact of three different separate collection systems – such as kerbside collections, and new collection points – for used textiles on the Irish market.
- [NU Wardrobe](#) provide an online platform for peer-to-peer clothes swapping in Ireland.
- [Pearl Reddington](#) – produces Irish designed and produced knitwear. The company now offers [repair services](#) for its garments to extend their life.
- [Thriftify](#) is an online platform that creates a movement of positive purchasing by connecting charity shops with consumers who care.

Benefits of Circularising Ireland's the Fashion and Textiles Sector

Expanding Ireland's circular fashion and textiles sector presents several opportunities to achieve key social, economic and environmental impacts. The model has potential to considerably benefit Ireland's environment by reducing the disposal of textile waste to landfills, whilst helping to decarbonize the sector through repurposing, reuse, and prevention actions.

Analysis of global material flows of textile fibres by EMF found that just 13 percent of the world's fibre input for clothing is recycled (EMF, 2017b). Consequently, an estimated \$500 billion value is lost globally every year due to barely work clothing being discarded and seldom recycled at end-of-life. The recapturing this value is the basis behind the claims of industry collectives, such as the Circular Fashion Summit (CFS), that the global circular fashion industry has the potential to become

a US\$5 trillion market by 2030 (CFS, 2020). Emergent market trends suggest this shift is already underway. For instance, fashion resale grew at a pace twenty-one times faster than apparel retail between 2017 and 2020. Selling used clothing alongside new clothing is thus predicted to become the new normal (CFS, 2020). Meanwhile, the global recycled textile industry was pegged at \$5.3 billion in 2018, and is expected to reach \$8 billion by 2026, growing at a CAGR of 5.3% from 2019 to 2026 (EMF, 2017a).

Beyond the commercial opportunities, advancing a circular fashion and textiles economy through the pursuit of various circular strategies unlocks alternative sources for secondary raw materials that actively reduce demand for natural virgin resources. This reduced reliance on virgin raw materials additionally reduces the greenhouse gas emissions associated with upstream material extraction, manufacturing and transport and improved end of use management.

For the local economy, the circular economy interventions of waste prevention can contribute to a more sustainable model of consumption. The circular economy promotes the use of safer, renewable, or recycled materials, minimizes demand for non-renewable natural resources, and seeks to minimise greenhouse gas emissions. Efforts are made to place restrictions on which chemicals can be used in textile production, to reduce the risks of environmental contamination through toxins (such as chemicals and dyes used in manufacturing, and in chemical textile recycling).

Tangible socio-economic benefits are expected for those countries willing to invest in the infrastructure and technologies needed to support the development of circular fashion and textiles domestically. For instance, transitioning to a circular economy is estimated to create at least €1.5 – 2.5 billion growth potential per year for the Finnish economy (Kämäräinen, 2020). Meanwhile, by 2025, while it is estimated that Finland's domestic textile ecosystem could create as many as 17,000 new jobs in the country (LSJH, 2022). Further, a circular economy supports the investment in infrastructure and better facilities to support the growing economy (Dept. of Communications Climate Action and Environment, 2019). The Whole of Government Strategy for a Circular Economy, for instance, acknowledges that the use of textile waste as a secondary raw material can provide opportunities for new domestic manufacturing (Government of Ireland, 2021).

Key Stakeholders

Any efforts to circularise Ireland's fashion and textiles industry will require engagement and input from the following key stakeholders:

- **Environmental Protection Agency (EPA):** Textiles are one of the priority product value chains in the EPA's Circular Economy Programme. The EPA as part of its remit to inform national policy and address knowledge gaps has undertaken measures such as commissioning a study to determine the nature and extent of post-consumer textiles in Ireland to inform future consultations

and measures identified in national policy Waste Action Plan for a Circular Economy. Meanwhile, the EPA's Green Enterprise Innovation Fund prioritises textiles as of its priority thematic areas ([Environmental Protection Agency, 2021](#)).

- **Design & Crafts Council of Ireland (DCCI)** is the national agency for the commercial development of Irish designers and makers, stimulating innovation, championing design thinking and informing Government policy. In 2021, DCCI joined the CIRCULÉIRE network, as part of the agency's wider commitment to promoting and raising awareness of the concept and benefits of circular economy amongst its circa 800 industry members.
- **Textile producers, fashion brands, designers and retailers** all play a role in advancing a circular economy and Ireland, and in helping to close the loop on textile waste in Ireland.
- **Circular Fashion and Textile businesses**
- **The Irish Charity Shop Association (ICSA)** comprises 450 charity stores across the country. The association represents a major stakeholder actively contributing to the circular economy concept of reusing and recycling (Dept. of Communications Climate Action and Environment, 2019). Collaborations to facilitate reuse of garments exist between ICSA members and retailers such as Enable Ireland and TK Maxx, and SVP and Brown Thomas ([Environmental Protection Agency, 2021](#)).
- **Textile recyclers** (of which there are at least five commercial operators on the island of Ireland). It is significant to note however that recycling activities occurring in Ireland are minimal, and most post-consumer textiles collected being baled and exported, primarily to African countries ([Environmental Protection Agency, 2021](#)).
- **Community Reuse Network Ireland (CRNI)** is a nationwide representation of a network of community-based interventions in the reuse, recycling, and active minimisation of waste.
- **Policymakers, regulators, funders**
- **Universities and Higher Education Institutions** – to ensure that circularity thinking and design principles are integrated into various educational programmes such as Fashion Design, Textiles, Fashion Buying & Merchandising, Marketing (etc.)
- **Consumers**

Policy Drivers and Government Support

Government policies and regulations play an essential role in enabling a circular economy for fashion and textiles, and in setting the strategic direction of national funding and investments in innovation. At the national policy level, the concept of circular economy has been applied to fashion and textiles through key policy documents, such as the [Waste Action Plan for a Circular Economy](#). An increasing number of circular economy public grant funding is coming on stream that take textiles as one of their priority thematic areas for circular innovation (such as the EPA's Green Enterprise Innovation Fund and DECC's Circular Economy

Innovation Grant Scheme). The European Circular Economy Action Plan 2021-2027 (CEAP) operates as a guiding framework for much of the national policies which aim to support Ireland's transition into a circular economy (Environment Protection Agency, 2021). While broader in focus, the CEAP includes targeted measures to promote circular fashion and textiles with the acknowledgement that Europe's textile sector is amongst the most resource intensive, where the potential for circularity is high. It puts forward the need for a comprehensive EU Strategy for Textiles, which is outlined in greater detail below.

Making sustainable products the norm in a more resilient Single Market



Overview of initiatives in the Circular Economy package ([CoR, 2022](#)).

Below we summarise some of the key national and European-level policies, protocols and regulations that are driving circular fashion and textiles in Ireland and beyond:

Waste Action Plan for the Circular Economy - (WAPCE)

The WAPCE is a roadmap aimed at shifting Ireland's waste management and planning policy approach away from waste disposal towards preserving the resources and transitioning to a low-carbon circular economy. The plan highlights specific actions aimed at supporting a circular economy for textiles in Ireland, such as working with Irish designers and retailers to promote eco-design for textiles and clothing, and establishing a Textiles Action Group to explore options to improve future circularity in textiles (OECD Publishing, 2021).

Whole of Government Circular Economy Strategy 2022 – 2023 'Living More, Using Less'

This is Ireland's first national circular economy strategy. It plays a central role in the Government's drive to achieve a 51% 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 - 2022](#). The purpose of this high-level, all-of-government strategy is to set a course for Ireland to transition across all sectors and to ensure policy coherence across at all levels of government and all policy levers towards circularity and sustainability ([DECC, 2021](#)).

EPA's Circular Economy Programme (2021-2027)

Delivered by the EPA, [this programme](#) builds upon the previous National Waste Prevention Programme to support national-level, strategic programmes to prevent waste and drive the Circular Economy in Ireland. The Programme was established to make progress on the commitments within the Waste Action Plan for a Circular Economy and to reconfigure the National Waste Prevention Programme into Ireland's The Circular Economy Programme (EPA, 2021). Since textiles are one of the priority product value chains in the EPA's Circular Economy Programme, the EPA has outlined several measures to ensure the circularity in textile management. such as commissioning a study to determine the [nature and extent of post-consumer textiles in Ireland](#) to inform future consultations and measures identified in the [national policy Waste Action Plan for a Circular Economy](#).

European Waste Framework Directive (WFD)

The WFD requires that Member States set up separate waste collection for priority value streams (such as paper, plastic and WEEE) "to avoid waste treatment which locks in resources at the lower levels of the waste hierarchy, increase preparing for re-use and recycling rates, enable high-quality recycling and boost the uptake of quality secondary raw materials..." ([Interreg, 2020](#)). As of 2025, it will become mandatory for all Member States to have separate waste collection for all textile waste.

United Nations Sustainable Development Goals (SDGs)

The manner in which we manufacture, (re)use, dispose of, or recycle our textiles has an influence on practically all Sustainable Development targets. For the textile industry, "SDG 12: Responsible Consumption and Production" provides a doorway to many of the other SDGs for the textile sector. More sustainable, ethically and environmentally-friendly cultivation and production of cotton, wool, timber, and other natural raw materials is aligned with the aims of "SDG 15: Life on Land" and "SDG 8: Decent Work and Economic Growth". Converting to renewable energy and employing cleaner technologies in the fibre processing phases benefit the aims of "SDG 6: Clean Water and Sanitation," "SDG 9: Industries, Innovation, and Infrastructure," and "SDG 13: Climate Action". While supporting the advancement

of a circular fashion and textiles by cutting out waste, keeping materials in use longer, and renewing agriculture is a prerequisite to lowering carbon emissions, a major aim of "SDG 13: Climate Action".

Some European strategies and forthcoming regulations will have a considerable bearing in driving circular fashion and textiles. These include:

EU Strategy for Sustainable and Circular Textiles

The Strategy is a non-binding document elaborated in line with the [EU Green Deal](#), Circular Economy Action Plan, the Industrial Strategy and the Chemicals Strategy for Sustainability (EC, 2021a), which aims to create a coherent framework and vision for the transition of the textiles sector as a priority sector to undergo a sustainable, circular transition. The Strategy, which was published in 2022, puts in place the groundwork for a raft of proposed actions intended to boost circularity for the sector, such as:

- promoting more sustainable products, incentivising circular business models ('economically profitable re-use and repair services are widely available' ([EC, 2022](#))), curbing fast fashion, and by placing additional requirements on producers to take responsibility for their products all along the value chain.
- It highlights the need to develop product-specific Eco-design requirements to increase durability, reusability, reparability, fibre-to-fibre recyclability of textile products, while limiting the harmfulness of chemicals and materials used in their production (see ***Sustainable Products Initiative*** below).
- It proposes harmonised EU rules on extended producer responsibility for textiles, and economic incentives to make products more sustainable ("eco-modulation of fees"), as part of the revision of the Waste Framework Directive in 2023.
- Additional actions will support the vision at the heart of the Strategy, such as supporting research, innovation and investments in circular fashion and textiles innovations, by launching specific calls under R&I programmes, like Horizon Europe, to advance technologies and processes to scale up repair, improve collection and sorting, scale up textile recycling capacities of the EU industry, and increase fibre-to-fibre recycling and the uptake of recycled fibre content.

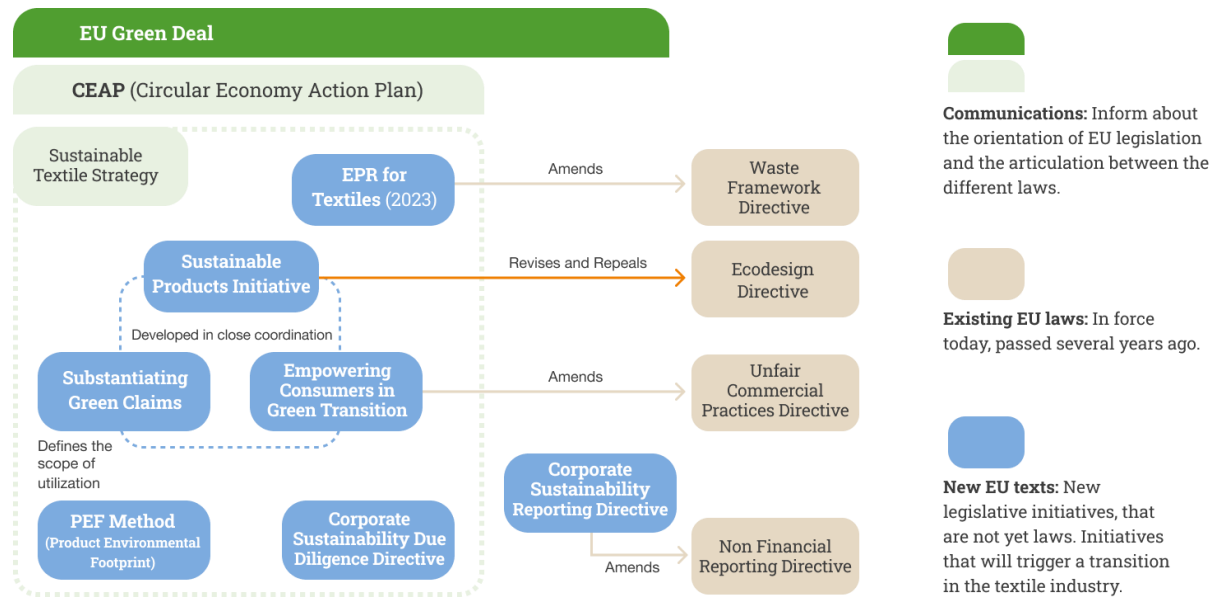


Image: How the EU Strategy for Textiles fits with EU Plans and Strategies. [Source: TrusTrace, 2022](#)

- Sustainable Products Initiative (SPI)** and proposed Eco-design for Sustainable Products Regulation (ESPR)

The SPI will extend the scope of the current Eco-design Directive – which focuses on energy-related products – to a broader range of goods, including textiles. The proposed ESPR regulation sets out minimum eco-design requirements, introducing new circularity requirements for producers to make priority products durable, reusable, recyclable, and repairable ([EURACTIV, 2022; 5](#)). It proposes new transparency requirements be introduced for companies that discard or destroy unsold consumer products – with a longer-term view to empower the European Commission to ultimately ban the disposal of groups of products that have significant environmental impacts ([EP, 2022](#)). Following the adoption and entry into force of the ESPR, and subject to impact assessment, it is expected that secondary legislation will set eco-design performance requirements for textile products, information requirements and a Digital Product Passport ([CoR, 2022](#)). Further targeted changes to textiles labelling will also be considered under the Textiles Labelling Regulation (*Ibid.*) At the time of writing, the Council of the European Union is debating on the legislative proposal ([EP, 2022](#)).

Purpose of this Guide

This Sectoral Guide is intended for those involved in Ireland's fashion and textiles industry, including economic operators in the value chain (such as retailers), and key decision-makers, such as funders and policymakers. It aims to provide industry stakeholders with an overview of good circular economy practices from the fashion and textiles sectors to inspire, increase knowledge & awareness and encourage replication and adoption of good practices from across Europe to the Irish context. For policymakers, the Guide is intended to draw attention to some of the key policy enablers which supporting the advancement of circular fashion and textiles

sectoral activity in other jurisdictions. In this guide, the following clusters which are driving circular innovations in the Fashion and Textiles sectors are given particular attention:

1. Circular materials, resources and inputs
2. Circular manufacturing processes
3. Circular business models in textile and fashion industry
4. End-of-use circular strategies

Methods

The report is based on information gathered using the following methods. An initial two-part scoping desktop review was conducted on:

1. the literature on circular economy in the fashion and textiles sectors
2. policies and public-sector led initiatives aimed at supporting circular fashion and textiles

The findings of the desktop review were used to refine our Sectoral Guide objectives and were used to develop key criteria to select our case studies, using purposeful sampling, and to develop our analytical framework. Key circular economy databases were identified and used to identify a long list of circular innovations in the fashion and textiles sector.

In the final stage of our research, we identified and selected case studies according to the following criteria:

Circularity of the project/ initiative	<p>In order to enable comparative analysis of the processes enabling different kinds of innovation, we sought to select projects which explicitly presented themselves as a circular innovation, pursued one or more circular economy strategies, and which illustrated circularity under on or more of the following 'layers':</p> <ol style="list-style-type: none"> 1. Circular Materials, Resources and Inputs 2. Circular manufacturing processes 3. Circular business models in textile and fashion industry 4. End of use circular strategies
Impact of the project/ initiative (proven or high potential)	<p>"Circularity" in and of itself does not guarantee positive social, economic, and environmental performance (i.e., sustainability) (Blum et al., 2020). Case studies were shortlisted on the basis that they overtly self-identified as circular innovations and have demonstrated an effort to create impact(s) against different social, economic and environmental impact indicators. Consideration was given to ensure projects and initiatives profiled demonstrated positive performance (proven or high-potential if scaled) against material waste and carbon emission</p>

	reductions. While we targeted examples of potential or established good practices, the aim of the case studies was not to evaluate projects or organisations - since even less 'successful' cases can yield important insights about existing barriers to implementing or scaling circular innovations.
Technological Readiness Levels (TRLs) of the Initiative	To gather information on both emergent / cutting-edge innovations and more established, 'market ready' circular fashion and textiles innovations, we selected case studies that were judged to range from TRL 6 – 9. This enabled us to gather insights about the opportunities and challenges (such as regulatory, scaling and replication challenges) from circular fashion and textile innovations at different stages of maturity.
Geographic variety	To analyse the processes associated with supporting circular fashion and textile innovations in different socio-economic and policy contexts, and in the context of different market and sectoral conditions, we select cases from a variety of regions (with a particular focus on European regions). Particular attention has been given to spotlight good practices originating or operating in other regions, nonetheless, the Guide also endeavours to highlight good practice examples of circular innovations identified within Ireland too.

The public sector examples profiled in section 3 were identified based on a desk-based policy landscaping exercise – and used as a basis for determining and benchmarking the range of systems levers that are being used by key decisionmakers to facilitate the development of enabling market conditions and innovation ecosystems for circular fashion and textiles. Comparative analysis was undertaken to understand processes and approaches that have been adopted in these regions, and the insights gathered around the opportunities and gaps were used to inform the recommendations presented in section 3 about how the Fashion and Textiles Sector can be supported to transition to a circular economy in the Irish context.

Structure of the Guide

This Guide is structured as follows:

- Section 2 builds on desk research and summarises good practices of circular fashion and textiles innovations in action from Ireland and Europe.
- Section 3 draws on the lessons learnt from the case studies and from other contexts that have made good progress in advancing circular fashion and textiles. It offers recommendations about what's needed to advance a circular economy for the fashion and textiles sector here in Ireland.

Section 2: Circular Innovations in the Fashion & Textile Sector

This section highlights several fashion and textile industry case studies – from Ireland and elsewhere in the world- which illustrate how circular innovations are shaping and guiding the transition of the sector towards greater sustainability and circularity. The case studies profiled below are categorised by the following clusters of recognised circular innovation activity in the Fashion and Textiles sectors:

1. Circular materials, resources and inputs
2. Circular manufacturing process
3. Circular business models in the fashion and textile industry; and
4. End of use circular strategies

The cases cover various aspects of the production lifecycle of the fashion and textile sector. They were selected on the basis that they have demonstrated real or high potential performance against material waste and carbon emission reductions, as well as some additional economic, environmental and/or social indicators.

A more detailed description for each of these clusters, and the role they can play in advancing circular economy for the fashion and textiles sector in Ireland and Europe has been included in the subsequent pages. Table 2.1 below provides an overview of the case studies profiled in this Guide.

Table 2.1 Overview of the case studies

Cluster	Case study name (include project/website links)	Region covered	What are the top CE Strategies?	What is the TRL of the initiative?
Circular materials, resources and inputs	Mi Terro upcycling agricultural waste into biomaterials for the fashion industry	Production facilities in California, USA	Valorisation of organic waste material	TRL 7
	Spinnova developed textile fibres from renewable wood raw material (pulp)	Helsinki, Finland	Novel (biobased / biodegradable) material	TRL 8
	Teemill sets a traceable supply chain within T-shirts production	United Kingdom	Circular supply chain and traceable materials	TRL 9
Circular manufacturing process	Resortecs has adopted a 'design for disassembly' approach to produce thermally dissolvable thread for clothing	Belgium	Design for disassembly	TRL 8
	DyeCoo commercial water-free and process-chemical free-dyeing technology for textiles processes	Netherlands	Resource efficiency	TRL 9
	Infinna™ - using cellulose carbamate processes to produce a	Finland	Lean manufacturing	TRL 9

Cluster	Case study name (include project/website links)	Region covered	What are the top CE Strategies?	What is the TRL of the initiative?
	cotton-like and sustainable fibre out of post-consumer textile waste			
Circular business models	DressX provides a solution for social media content creation without the need for physical products.	USA	Digitization and virtualization; Resource Efficiency	TRL 8
	thredUP has initiated a buy back scheme for old clothes from any brand in US	USA	Buy Back scheme; Reverse Logistics	TRL 9
	Circos has introduced a subscription model for baby clothing where members pay a monthly	Netherlands; Europe	Product service system (PSS)	TRL 9
	Nudie Jeans Co Reuse and Repair programmes keep existing jeans in use for longer	Sweden; Worldwide	Take back scheme; Reuse; Repair	TRL9
End of use circular strategies	Renewal Workshop capturing value from unsellable inventory through renewing and upcycling products	Oregon, USA	Refurbishment	TRL 9

Cluster	Case study name (include project/website links)	Region covered	What are the top CE Strategies?	What is the TRL of the initiative?
	RESYNTEX using chemical recycling to recover secondary raw materials from unwearable textile waste	Slovenia, Belgium, Germany, France, UK	Depolymerization; Industrial Symbiosis	TRL 7

Cluster 1: Circular Materials, Resources and Inputs

Significant volumes of materials and resources are lost to landfill and incineration during the production of textiles, or at their end-of-use. Ireland generates around 170,000 tonnes of post-consumer textiles waste per year (including clothing, footwear, and other textile products) (EEA, 2020). This represents around 35 kg per Capita which is higher than the reported EU average of 26 kg per person per year (*ibid.*). It is unsurprising then that circular innovations are emerging that aim to address this circular opportunity, ensuring that material inputs for textiles are “safe and recycled or renewable” (PACE, 2021).

When looking at Circular Materials, Resources and Inputs, it is important to distinguish between biological and technical cycles (EMF, 2015). Biological cycles comprise materials that can be maintained, reused, repaired, and sometimes even recycled, but eventually they can be returned to the biological cycle from which they came.

Technical cycles refer to materials which present primary raw materials of limited availability and should be retained in use for as long as possible (e.g. such as synthetic or plastic fibres). Crucially, a technical barrier to circularising many textiles is that they blend technical and biological materials in such a way that we can't separate them and circulate them– for example, textiles that blend natural and plastic fibres (EMF, 2015).

The case studies profiled below various stages of the life cycle of the fashion and textile sector including upstream cultivation and processing of raw materials, the manufacturing processes and downstream processes (e.g. leveraging digital platforms to support production of fabrics based on textile-to-textile recycling processes). The following case studies offer real-world examples of circular innovations occurring at the material and resources level:

- Circular venture, Mi-Terro, upcycles agricultural waste into biomaterials for the fashion industry
- Finnish startup, Spinnova, developed textile fibres from renewable wood raw material (pulp) making a material innovation
- Teemill uses regenerative farming practices and technology to improve the resource efficiency, sustainability and recyclability of its cotton inputs

Case Study 1: Mi Terro - upcycling agricultural waste into biomaterials for the fashion industry

Website: <https://www.miterro.com/>

Partner(s) involved: No Partners Involved

CE Strategies used: Valorisation of Organic Waste Material

Type of CE innovation: Product innovation

Region(s): USA

TRL: 7

What circular challenge / opportunity is the case study trying to address?

Considerable volumes of milk are spoiled, wasted or deemed surplus every year. In 2020 alone, an estimated 2.7 million to 3.7 million gallons of milk was wasted in the US due to decreased demand or other reasons (Wiener-Bronner, 2020). Circular economy startup, Mi Terro, seizes this circular opportunity by introducing a technology which converts the spoiled or wasted milk into biodegradable fibre. This fibre is used to produce biodegradable biomaterials and garments, like t-shirts. As such, Mi Terro's technology and product innovations reduce spoiled milk wastage through the development of novel biodegradable textiles (miterro, 2020).

Background of the initiative

The Mi Terro venture was established in California (USA) in 2019. Agricultural waste, such as spoiled milk, is utilised by Mi Terro to develop a novel milk-to-clothing industrial process. After collecting spoiled and surplus milk from a variety of dairy farms, Mi Terro's patented three step production process converts the milk amino acids (particularly casein) into a yarn. Their first step, Pro-Act (Protein Activation) is a technology which extracts casein molecules from 'bad' milk. After the protein has been extracted, it is purified using Sea-Re (Self-assembly Purification) to turn it into a usable molecule in preparation for spinning using a process called Dynamic Flow Shear Spinning (DFS) which transforms the protein into a sustainable fibre. In recent years, Mi Terro's research and development team have created and tested yarn prototypes made from spoiled milk. The first version of their milk-to-clothing process took two months to complete, with ongoing work being undertaken to continue improving the performance of the fabric. Mi Terro is developing a second fibre which is "blended with viscose which has its own natural properties that will help it to boost the performance of [Mi Terro's] fibre and make it cheaper than organic cotton or modal" (Harrison, 2021).

Impact and maturity of the initiative

Production of Mi Terro's milk-based fabric requires 60% less water than organic cotton does, and is 100% biodegradable, with zero petroleum-based chemicals involved in the process (HARRISON, 2021). Mi Terro has achieved a reduction in environmental impacts as tonnes of waste is generated by the spoiled milk and other dairy items waste. Currently, their fabric is made from around 15-20% of spoiled milk, with one glass of milk making up five T-shirts (Lampoon, 2021).

The company supports sustainable development, by reinvesting 1% of their profit to charities tackling food waste through [1% for the Planet](#), a membership initiative that enables businesses to donate a percentage of their gross sales to environmental non-profits that are rigorously vetted on their planetary impact. Moreover, it has committed to planting 15 trees for every purchase in partnership with Eden Reforestation Projects.

Case Study 2: Spinnova – developing novel bio-based textile fibres from renewable wood raw material (pulp)

Website: <https://spinnova.com/>

Partner(s) involved: EURATEX

CE Strategies used: Biodegradable Materials

Type of CE innovation: Material innovations

Region(s): Helsinki, Finland

TRL: 8

What circular challenge / opportunity is the case study trying to address?

Around half a million tonnes of plastic microfibres are released from washing synthetic textiles into our oceans annually (EMF, 2017a). Production of fibre from virgin natural resources, like cotton, also poses major environmental impacts globally. A circular opportunity therefore exists in using by-products from the forest industry and recovered paper in the manufacturing of textiles. Spinnova, a fibre technology company, has developed a solution that enables textile fibre production out of wood but also from textile waste or agricultural waste such as wheat or barley straw (Spinnova, 2021).

Background

Spinnova was started in Helsinki, Finland in 2009. The company has developed a textile fibre directly out of biomaterials without the need for harmful chemical processing or dissolving, which limit the recycling of biomaterials. The raw material of the fibre is pulp from FSC certified wood or waste streams, such as agricultural waste. The pulp is mechanically refined into a very fine, paste-like material. Finely ground pulp mass flows through a nozzle, where the fibres rotate and align with the flow, creating a strong, elastic fibre network. The end-result is a strong white filament with cotton-like strength, stretch characteristics, and thermal properties similar to wool fibres. Depending on the application, fibres could be water repellent, dyed before a wet spinning phase or have higher water absorption capacity (Spinnova, 2019).

Impact and maturity of the initiative

Spinnova's process uses no harmful chemicals and 99% less water than the cotton value chain. Spinnova claims the resultant fibre is one of the most sustainable textile fibres on the market based on the following features: (i) the fibre creates minimal CO₂ emissions, (ii) it is biodegradable, (iii) it contains no microplastics, and (iv) it can be recycled into a new fibre again and again (Spinnova Oy, 2019). In 2021, Spinnova and the world's largest wood pulp producer, Suzano, announced an estimated €22 million investment to build the first commercial scale Spinnova® production facility in Jyväskylä, Finland. Spinnova's sustainable fibre will be available for global textile brands in 2022 (EURATEX, 2021). While Spinnova currently only uses wood pulp from sustainably managed forests, in future they plan to look at sourcing their cellulose from agricultural and bio-waste. The initiative has set a goal to achieve cellulose-based fibre production by 2030 (Spinnova, 2018).

Case Study 3: Teemill uses regenerative farming practices and technology to improve the resource efficiency, sustainability and recyclability of its cotton inputs

Website: <https://teemill.com/circular-fashion/>

Partner(s) involved: Retailers

CE Strategies used: Circular supply chain and traceable materials

Type of CE innovation: Process and technology innovation

Region(s): United Kingdom; India

TRL: 9

What circular challenge / opportunity is the case study trying to address?

New cotton garments rely on virgin fibres which ultimately come from agricultural production, and are highly land, water and resource intensive. Although still in its infancy, textiles recycling has a role to play in reducing chemical use and greenhouse gas emissions in production where part of the virgin material inputs are replaced (Sandin and Peters, 2018). Circular fashion business, Teemill, combines regenerative farming practices with garment-to-garment recycling to produce T-shirts that are supported by open access, circular supply chain (Ellen MacArthur Foundation, 2020a).

Background of the initiative

Teemill is a UK tech-based fashion business that takes a more holistic view of the fashion industry. Established in 2009, Teemill designs out waste at each step of the material supply chain, applying made-to-order technology solutions to minimise overstocking and waste, whilst maximising material recycling. By making its circular supply chain platform open access, Teemill has allowed tens of thousands of brands, charities and fashion start-ups to produce t-shirts more sustainably in real time overseas in India. Teemill's t-shirts are designed to be traceable so that they can be sent back and remade when they're worn out. Teemill's cotton farms in Northern India use regenerative farming practices. Cotton is grown using organic fertilisers, irrigated through rainwater harvesting, and protected using insect traps rather than pesticides. Co-planting with other crops helps fix nutrients and assists with pest control. The processing of the harvested cotton from fibres into materials generates by-products, including seeds, which are used to make vegetable oil and feed for cattle, thereby creating extra value and returning nutrients to the natural system. Teemill's factories recover, clean, and recirculate processed water in a closed-loop process, so that any water discharged from the factory is claimed to be safe to drink.

Impact and maturity of the initiative

Approximately 7.23 kg of CO₂ and 4478 litres of water is saved per Teemill tee that has been remilled. The company uses paper-based packaging and is increasingly using waste material from production. Teemill's operations are powered by renewable energy, displacing fossil use and eliminating carbon emissions. Its UK manufacturing operations are solar-powered, while its Indian factory operates two wind farms and a 150kw PV solar array (Teemill, 2021). Teemill saves further energy through the implementation of smart factory

technology, which dynamically turns machines on and off (Teemill, 2021). Teemill makes use of other technologies, such as QR code scans to trace and manage reverse logistics for its products. Teemill's vocational training programmes have helped over 40 young people on the Isle of Wight into full time work (ECESP, 2019).

Cluster 2: Circular Manufacturing Processes

In a circular fashion and textiles economy, recovery of materials and products is not only addressed at end of use, but is enabled at the design and productions stages

Pre-consumer zero-waste fashion manufacturing approaches are incorporated at the design and production stages to limit the waste produced. This can include the use of technology such as whole garment knitting, re-using off-cuts right at the production facility, whilst shifting towards innovative “green” chemicals, over harmful hazardous inputs. Furthermore, consideration is given to ensuring the design of garments supports post-consumer zero waste outcomes too, such as selecting singular fibre materials for garments (to better support recycling) and ensuring designing items with design for disassembly or recycling considerations in mind.

The following cases studies are profiled below, which cover various aspects of circular manufacturing process innovation:

- Resortecs has adopted a ‘design for disassembly’ approach to produce thermally dissolvable thread for clothing
- DyeCoo is a commercial water-free and process-chemical free-dyeing technology for textile processing
- Infinna™ - using green chemistry to produce a cotton-like and sustainable fibre out of post-consumer textile waste

Case Study 4: Resortecs has designed a new type of thread that makes the disassembly process easier where the thread dissolved using a commercial oven

Website: <https://resortecs.com/>

Partner(s) involved: No Partners Involved

CE Strategies used: Design for disassembly

Type of CE innovation: Service/Material Innovation

Region(s): Ghent, Belgium

TRL: 8

What circular challenge / opportunity is the case study trying to address?

Currently, just about 1% of all clothing is recycled to a high standard. The rest is downcycled, burned, or landfilled, resulting in an annual material loss of circa \$500 billion (EMF, 2021). Meanwhile, the disassembly of goods while recycling requires immense amount of energy and resources. Furthermore, according to industry research, which includes data from garment recycling companies, between 30-52% of a fibre like denim is lost during disassembly. In addition, the requirement to manually disassemble garments with thread means it is also a labour intensive and costly process (EMF, 2017). Resortecs' circular innovation is a thermal dissolvable thread for garments that aims to improve efficiency and reduce costs for textiles recycling and disassembly (Francesco and Vanhoeck, 2021).

Background of the initiative

Established in Belgium in 2017, Resortecs is an award-winning technology startup that enables smart, industrial-scale textile disassembly, sorting and recycling. Resortecs has designed a novel thread that improves the ease of disassembling textile garments – thereby reducing time and labour costs associated with disassembly. Their threads are available for different melting-points (150°C, 170°C and 200°C) and dissolved using a commercial oven. The choice of thread depends on the type of garment it is to be integrated into. The Resortecs® solution allows up to 500kg of garments (=>1000 pairs of jeans) to be dismantled at the same time (EMF, 2017).

Impact and maturity of the initiative

An independent comparative lifecycle analysis (LCA) of Resortec's technology to other recycling and disassembly methods, found that adopting thermal active disassembly can reduce CO₂ emissions by 50%, water consumption by 98%, and land use by almost 95% compared to landfill and incineration. It also found that requires 50% less energy and 50% less virgin raw materials (Ammar, 2019). The LCA study found that if the European garment share were thermally disassembled and properly recycled, up to 60.3 million tonnes of CO₂ could be avoided and over €2.3 billion could be saved per year (ReSorTecs, 2022). Moreover, it suggests that if the textile industry adopted Resortec's thermal disassembly technology, an absolute reduction of 204 million tonnes per year (10% of the 2.11 billion tonnes produced by the industry) of global emissions could be achieved in 10 years by simply switching the stitching thread used during

assembly ([ReSorTecs, 2022](#)). Resortecs' technology is a market-ready circular fashion solution. The company's bio-based and synthetic dissolvable threads and dismantlable rivet buttons are ready to be used by brands and require minimal-to-no technical adaptation. As of 2021, the company has reported its technology is being tested by over 25 global players in the fashion industry.

Case Study 5: DyeCoo a commercial water-free and process-chemical free-dyeing technology for textile processing

Website: <http://www.dyecoo.com/dyecoo-water-free-dyeing/>

Partner(s) involved: No Partners Involved

CE Strategies used: Resource Efficiency

Type of CE innovation: Process and technological innovation

Region(s): Netherlands

TRL: 9

What circular challenge / opportunity is the case study trying to address?

The textile sector is highly water intensive. The daily consumption of water in an average-sized textile plant producing about 8000 kg of fabric per day is 1.6 million litres (Kant, 2011). DyeCoo has developed a technology that uses zero water to dye textiles, a process that is otherwise often associated with the generation of toxic wastewater. In place of water, DyeCoo's innovation makes use of carbon dioxide as a solvent in a closed-loop system. Additionally, no process chemicals are needed, reducing the amount of chemicals used in comparison to conventional dyeing methods (Circulary, 2019).

Background of the initiative

DyeCoo has more than 15 years of experience in CO₂-based textile processing technology. DyeCoo uses a patented and industrial proven technology based on CO₂, instead of water, so no wastewater treatment is necessary. The technology uses reclaimed CO₂ from existing industrial processes as the dyeing medium, in a closed loop operation. When pressurised, CO₂ becomes supercritical (SC-CO₂), a state between a liquid and a gas. In this state CO₂ has a very high solvent power, allowing the dye to dissolve easily. Thanks to high permeability, the dyes are transported easily and deep into fibres, creating vibrant colours. CO₂ dyeing does not need added process chemicals to dissolve dyes. DyeCoo's technology uses 100% pure dyes and, with more than 98% uptake, nothing is wasted (ECESP, 2016a). The DyeCoo revenue model works by licensing its technology and machines to textile producing companies (Valuer, 2020).

Impact and maturity of the initiative

DyeCoo has achieved the following results:

- A single DyeCoo dyeing machine can save 32 million litres of water and 160 tonnes of processing chemicals per year. The total dyeing-capacity for a single machine is 800 tonnes of synthetic substrate (Circulary, 2019).
- **Energy efficiency:** CO₂ dyeing is a dry process, eliminating the need to evaporate water. The addition of efficient colour absorption and short batch cycles makes this technology more energy efficient than conventional dyeing processes.
- **Lower process costs:** short batch cycles, efficient dye use, no wastewater treatment all contribute to significantly reduced operating costs.

- **Vibrant colours:** DyeCoo uses 100% pure dyestuff, giving vibrant colours. The dyestuff penetrates deep into the fibres creating intense colours with excellent quality characteristics.

Besides the environmental – and circular benefits, CO₂ dyeing technology is the “linking pin” within the textile supply chain. The aim is to create more partnerships to reach the common goal of getting the textile industry completely circular.

Case Study 6: Infinna™ - using cellulose carbamate processes to produce a cotton-like and sustainable fibre out of post-consumer textile waste

Website: <https://infinitefiber.com/>

Partner(s) involved: H&M Group, GANNI & PVH

CE Strategies used: Lean Manufacturing

Type of CE innovation: Process innovation

Region(s): Finland

TRL: 9

What circular challenge / opportunity is the case study trying to address?

Every year, 100 million kilograms of textile waste is produced in Finland (Kokkonen, 2021), which puts extreme pressure on national waste management centres. IFC has established a production setup for textile-to-textile recycling from post-consumer waste in Finland. Its technology captures the valuable resources in discarded textiles, regenerating them into new, high-quality textile fibres with the look and feel of cotton (IFC, 2019).

Background

Infinite Fiber (IFC) was set up in Finland in 2016. Its novel fibres are called Infinna™. They are made of cellulose meaning they are biodegradable and contain no plastics. Infinite Fiber Company's cellulose carbamate production process uses responsible chemistry, and the created textile fibre has unique characteristics, including antimicrobial properties.

The resulting Infinna™ fabric is versatile like cotton, making it an alternative to conventional virgin fibres for a whole range of fabrics from single jersey and French terry to denim and woven fabrics, and non-woven applications such as soft hygiene products and wipes. Infinna™ can be used as a singular fabric regenerated 100% from textile waste, and blends well with conventional fibres like cotton. At the end of their life cycle, textiles made with Infinna™ can be regenerated in the same process alongside cotton-rich textile waste. IFC's technology is flexible in terms of feedstock. The raw material needed to create Infinna™ is cellulose, which is abundant in several waste streams, cotton-rich textiles; used cardboard, paper, and even agricultural residues like wheat and rice straw are all potential future feedstock options (ECESP, 2016b).

Impact and maturity of the initiative

Infinna™ reduces reliance on virgin materials and on natural resources. This decreases the amount of textile waste ending up as pollution at landfills and in incinerators (ECESP, 2016b). Infinna™'s end product enables the textile industry to raise the proportion of textile fibres created from pre- and post-consumer

textile waste, which in 2020 sat at less than 0.5% of all textile fibres produced globally.

As of 2021, the company operated pilot plants only in Finland, but has announced plans to build a flagship factory to meet the strong demand from international clothing brands (Kokkonen, 2021). Following a successful financing round in June 2021, IFC secured €30 million from investors, including adidas, H&M Group and Sateri (IFC, 2021). This funding will support the expansion of the company's existing pilots and scale up production by building its first factory. With an anticipated opening date of 2024, the new factory will have an annual production capacity of 30,000 tonnes, which is enough fibre to produce roughly 100 million T-shirts from Infinna™ using post-consumer textile waste as feedstock (*Ibid*).

Cluster 3: Circular Business Models in Textile and Fashion Industry

Fashion and textiles companies looking to adapt to a circular economy need to rethink their business models. Indeed, recent trends have seen textile apparel retailers shift away from mere sales of fashion goods towards service-based business models, emphasising access over ownership to prolong the product use-phase. This may, for instance, include renting of garments to consumers via clothing libraries (example: tuxedos for rent for special occasions) or leasing services for which consumers pay a monthly fee in exchange for access to a garment. Furthermore, repair and reuse concepts become more pronounced at the business-level, e.g. by offering repair kits and services as well as reselling products that had been in use before.

The following cases have initiated innovative circular fashion and textiles business models:

- Digital platform, DressX, uses B2B digital fashion to generate virtual garments that require no raw materials
- thredUP has initiated a buy back scheme for old clothes from any brand in US to reintroduce them to the original processing and manufacturing cycle.
- Circos has introduced a subscription model for baby clothing where members pay a monthly fee to access a range of high-quality clothing from different brands and reduce the pressure on virgin material resources.
- Nudie Jeans Co has a take back scheme that enables consumers to return or repair their jeans.

Case Study 7: DRESSX - using B2B digital fashion to generate virtual garments that require no raw materials

Website: <https://dressx.com/pages/sustainability>

Partner(s) involved: No Partners Involved

CE Strategies used: Digitization and virtualization, Resource Efficiency

Type of CE innovation: ICT innovation

Region(s): USA; Worldwide

TRL: 8

What circular challenge / opportunity is the case study trying to address?

An increasing number of fashion brands are turning from traditional print advertising to digital advertisements. Here, social media influencers play an increasingly central role in reaching consumers and driving sales. A side effect of this drive to create new social media content around fashion looks is that barely worn garments are often discarded. Research undertaken by Barclays found that 9% of clothing purchased by its credit card customers were bought for content creation to be returned afterwards (EMF, 2021). While a 2019 global survey of fashion influencers found that 81.9% of respondents believe in disposing clothes or accessories they no longer use ([SocialPubli, 2019](#)). DRESSX seeks to provide clothes that exist in their digital-only versions (EMF, 2021). With the help of DRESSX, the creation of items that might only be worn once or twice is decoupled from the extraction of raw materials.

Background of the initiative

DRESSX is a digital fashion company that uses virtual garments for social media advertisements. It was launched in 2020 as a global digital fashion multi-brand retailer which carries digital fashion collections from modern companies and designers. Digital fashion is created using 3D modelling software to create virtual clothes that emulate actual apparel. Additionally, the business provides packages to brands so that they can outfit their influencers virtually rather than physically. DRESSX's software has made it even simpler to create content using new clothes: In augmented reality (AR), digital looks can be created for real-time videos and photos. Currently, DRESSX is working with designers on other B2B use cases. For instance, eliminating production of samples and digitalising new collections, developing the collections from scratch so there is not a requirement for wholesale production to be done physically. DRESSX can also enable brands to get pre-orders from customers online before they produce a physical item and facilitate on-demand production. At the same time, digital patterns can also be used for physical production (EMF, 2020b).

Impact and maturity of the initiative

No water or chemicals are used for the creation or usage of digital fashion, and the production of a digital garment, on average, leaves 97% less CO₂ footprint and no microplastic shedding or soil degradation, compared to the production of a physical garment (EMF, 2020b). With 150 designers on board and more than 1,500 items available on the platform as of 2020, DRESSX has served thousands of orders, while in beta stage. On average, a designer will save 70% of their

monetary budget by creating their collection digitally. Similarly, with digital influencer gifting, costs for a campaign are reduced by 60%. 54% of people that purchased a digital garment in 2020 would like to buy another one (EMF, 2020b).

Case Study 8: thredUP has initiated a buy back scheme for old clothes from any brand in US

Website: <https://www.thredup.com/>

Partner(s) involved: No Partners Involved

CE Strategies used: Buy Back Scheme; Reverse Logistics

Type of CE innovation: ICT innovation

Region(s): USA

TRL: 9

What circular challenge / opportunity is the case study trying to address?

According to the USEPA, Americans create 16 million tonnes of textile waste each year, accounting for slightly over 6% of the country's total municipal waste (EIMF, 2009). Based on these figures, thredUP estimated that if everyone in the US bought one item used instead of new in 2020 it would save 3.6Mts of CO₂e (equivalent to 66 million trees planted), 100 billion litres of water (1.25B showers), and 200 million kilos of waste (18,700 full garbage trucks) (EMF, 2009). thredUP is an initiative that brings buy back scheme for old clothes from any US clothing brand, reintroducing them to the original processing and manufacturing cycle. In doing so, thredUP unlocks and maintains the embedded value of existing apparel items and reduces the pressure on virgin material resources.

Background of the initiative

thredUP is an online [Resale-as-a-Service platform](#), which was launched in the US in 2009. thredUP has designed a modern resale experience as one of the largest online platforms for women's and children's apparel. Through its managed marketplace, thredUP has created a smarter and easier way to buy and sell second-hand clothes. thredUP sellers send in pre-loved clothes from any brand for free. thredUP then processes these items, carrying out quality inspections, itemisation, price analysis, storage and listings, so they can be resold. thredUP buyers gain access to an ever-changing assortment of high-quality, low-price clothes from more than 35,000 brands. This industry is dependent upon other stakeholders such as public members to buy back or return back the used branded clothes (EMF, 2009).

Impact and maturity of the initiative

thredUP's thrifting marketplace and Resale-As-A-Service offering have enabled the company to achieve considerable impacts to date including: processing circa 100 million garments so far and 1 lbs (or 45.3 thousand metric tonnes) of CO₂e displaced ([thredUP, 2021](#)). thredUP customers have made \$3.3 billion in savings from its garments' estimated retail value. According to the thredUP 2021 resale report, the value of the US re-commerce market was \$36 billion in 2021 and is projected to double in the next five years reaching \$77 billion by 2025 (thredUP, 2021).

Case Study 9: Circos - a monthly subscription model for high-quality baby clothing

Website: <https://circos.co/>

Partner(s) involved: PlanMiljø

CE Strategies used: Product service system (PSS)

Type of CE innovation: ICT innovation

Region(s): Netherlands; Europe

TRL: 9

What circular challenge / opportunity is the case study trying to address?

In the first two years of life, an average infant needs 280 pieces of clothing, most of which are only worn for about two or three months (EMF, 2019). Consequently, vast amounts of children's clothing end up in landfills, losing value and contributing to negative environmental impacts. Circos' circular business model is premised on a rental system for children's and infants' clothing, ensuring the high-quality garments it leases are kept in use for a longer period of time.

Background of the initiative

Circos is an online platform established in the Netherlands in 2019. It offers a subscription service for high-quality children's and maternity wear. Children grow out of their clothes quickly; to avoid the textile waste associated with this, Circos enables its customers to return and swap items for larger sized collection as their child grows. Parents who opt for the company's monthly subscription package can choose from a selection of more than 500 items on its website from different brands, based around the child's size. The choice of package ranges from 12 to 24 items a month, representing about 40 - 100% of the child's clothing needs. Each clothing bundle is delivered to their door in a reusable and compostable bag (EMF, 2019). This method increases the use and prolongs the lifetime of clothes where the worn items can be returned to Circos for material repurposing.

Impact and maturity of the initiative

In addition to the cost savings Circos' customers make, subscribers to the service make average savings of 70%, and an 80% carbon footprint reduction by renting instead of buying its garments ([Circos, 2021](#)). The company commissioned Danish consultancy firm, PlanMiljø to undertake a lifecycle assessment. This demonstrated that Circos' users save an average of 242 litres of water, 270 grams of cotton and 6.14 kilos of CO₂e per month compared to parents who buy all their children's clothing as new (EMF, 2019).

Case Study 10: Nudie Jeans Co running a take back scheme to collect post-consumer jeans from customers

Website: <https://www.nudiejeans.com>

Partner(s) involved: No Partners Involved

CE Strategies used: Take back scheme; Reuse; Repair

Type of CE innovation: Business model innovation

Region(s): Sweden; Europe

TRL: 8

What circular challenge / opportunity is the case study trying to address?

The amount of waste jeans generated annually is estimated as 2.16 million tonnes, with only 35–50% of this amount collected in Western Europe being reused or recycled after sorting ([Uncu Aki et al., 2020](#)). A pair of such jeans can remain without degrading in the environment for a very long time, meaning the negative environmental impact of discarded jeans is very high (*Ibid.*)

Nudie Jeans Co. innovative business model seeks to circularise jeans, in two key ways: first, they extend the life of their jeans through the take-back scheme they launched to integrate post-consumer jeans into their fabric at their end of use. Second, they have launched a repair service to extend the life of their existing jeans.

Background of the initiative

Set up in Sweden in 2001, Nudie's mission is to take responsibility for their own waste, by collecting their old, worn-out jeans from customers to make into new jeans. They will also pre-loved denim items from other brands, regardless of their condition, and recycle them into new jeans.

In addition to its recycling programme, in recent years Nudie's circular business model has led the company to look at ways to extend the life of its existing jeans, rather than selling new jeans. Since 2012 – 2013, Nudie has offered Reuse and Repair services to its customers.

Nudie's Reuse offering involves washing, repairing and re-selling pre-loved Nudie Jeans as second-hand. Pre-loved Nudie Jeans can be exchanged for a 20% Reuse-discount off a new pair of jeans. Reuse jeans (second-hand jeans) can be bought in stores or occasionally online ([Nudie, 2022](#)). In 2018, Nudies launched its Repair Shops concept. The idea is for them to serve as hubs where the brand's jeans are repaired, resold as second-hand products, or handed into the Nudie Jeans Reuse programme ([Nudie, 2021](#)). Nudie jeans come with a lifetime guarantee of free repairs, regardless of whether they were pre-loved or not.

Impact and maturity of the initiative

In 2021, Nudie's Repair locations repaired a total of 42,500 pairs of jeans. By repairing these jeans instead of producing new ones, the company saved approximately 34,000kg of cotton and 14.6 million litres of water ([Nudie, 2022](#)). Moreover, an independent LCA study undertaken for Nudie showed that a pair of jeans which are reused three times decrease the global warming potential by 60%, compared to a pair of jeans with zero reuses (i.e. where no repair actions have been used to prolong the life of the jeans). The general result, looking at different environmental impact categories, showed that the mitigated

environmental impact was found to be over 30% for a pair of jeans which are reused three times ([Nudie, 2022a](#)). Nudie has set an ambition to set up 50 new permanent “Repair Shops” by 2030 and is looking to increase jean repairs by 26 percent globally and increase jeans collected by 20 percent (Warren, 2021).

Cluster 4: End of Use Circular Strategies

End of use circular strategies are key waste prevention activities which include the checking, cleaning or repairing recovery operations, by which products or components of products are prepared so that they can be re-used without any other pre-processing (Len and Ardit, 2011). This can include processes of reducing a product all the way back to its basic materials, reprocessing those materials, and using them to make new circular products, components or materials (EMF, 2017).

The case studies highlighted below demonstrate a range of circular innovations that are emerging in downstream processes, such as mechanical and chemical recycling, upcycling and reuse. Mechanical recycling is the process of repurposing textile fabric into fibres without the use of chemicals. To extract fibres from the fabric, this process includes shredding and carding (ECAP, 2019). While more established in practice, there are disadvantages to mechanical recycling, such as that the fibre becomes shorter, reducing quality. Chemical recycling, on the other hand, includes a series of chemical processes which are used to separate and recycle blended fabrics. Chemical recycling remains at a lower TRL due to its high expenses and technical barriers.

Despite the challenges posed by both textile recycling approaches, textile-to-textile recycling can be successfully undertaken and is seen as a part of a package of actions, including improved sorting and recycling technologies, needed to close material loops and retain the material quality of textiles for as long as possible.

Importantly, a key success factor is collaboration across the value chain, from brand and retailers to garment makers to yarn and fabric suppliers, and from collectors to recyclers (ECAP, 2019). Below we profile circular innovations which are looking to circularise the fashion and textiles value chain at their end-of-use:

- Renewal Workshop captures value from unsellable inventory through renewing and upcycling products
- Horizon 2020-funded project, RESYNTEX, used novel chemical recycling to recover secondary raw materials from unwearable textile waste, while investigating market opportunities for industrial symbiosis between key parts of the textiles value chain.

Case Study 11: Renewal Workshop***Capturing value from unsellable inventory through renewing and upcycling products*****Website:** <https://renewalworkshop.com/>**Partner(s) involved:** North Face Renewed, The Cos Restore Collection**CE Strategies used:** Refurbishment**Type of CE innovation:** Business model innovation**Region(s):** Oregon, USA**TRL:** 9**What circular challenge / opportunity is the case study trying to address?**

Refused items are a common source of textiles waste where over 70% of all clothes produced are landfilled or incinerated after use. For instance, the British luxury brand Burberry, destroyed \$36.8 million worth of its own unsold garments, due the overproduction, while fast-fashion retailer H&M is claimed to have [burned 60 tonnes of new and unsold clothes](#) in a 5-year period between 2013 - 2018 (Lieber, 2018).

Renewal Workshop aims to address this linear challenge, by capturing the value from unsellable inventory through renewing and upcycling products (EIMF, 2016).

Background of the initiative

Renewal Workshop was set up in Oregon, USA in 2016. The company takes all of brand's unsaleable home items and garments and extends its lifespan by restoring the items, reusing materials, or recycling the textiles for feedstock. These items could come from customer returns, warranty claims, manufacturing defects, products from trade-in programmes, products damaged in shipping or at retail stores, amounting from hundreds to thousands to millions of items every year depending on the size of the brand (EMF, 2016). The clothes that come into the system are cleaned using advanced waterless cleaning technology. Then, half of the garments are professionally repaired and certified as new. Data is gathered on everything that passes through the system and provided to brand partners so they can enhance the production and design of future products. Renewal Workshop's mission is to keep clothing in use, eradicate the idea of waste, and recover all the value of what has already been produced in order to better serve clients, partners, and the environment. (EMF, 2016).

Impact and maturity of the initiative

Renewal Workshop considers renewal to be a cornerstone of the Fashion and Textile industry's decarbonisation efforts – and claims that brands can achieve an average reduction of 51.5% in carbon emissions by renewing an existing product instead of producing a new one (Renewal Workshop, 2021)

Renewal Workshop has diverted 500,000 lb (>225,000 kg) of apparel and textile waste from landfill, reaching 50% of its 2025 target which avoids more than 530,000 kg CO₂ greenhouse gas emissions and above 366,000,000 litres of water (Vertue Lab, 2019). The initiative has committed to displacing 10% of the partners' new production over the next 5 years and investing those resources into renewal

instead (Workshop, 2021). By offering turnkey solutions for brands to repurpose “unsellable” apparel and textiles, Renewable Workshop has been able to scale into new markets, such as The Netherlands, and initiated new partnerships quickly in support of its goal of creating a circular system and increasing the life of textiles (Vertue Lab, 2019)

Case Study 12: RESYNTEX using chemical recycling to recover secondary raw materials from unwearable textile waste

Website: <https://www.prospex-institute.org/resyntex>

Partner(s) involved: transnational project (spanning Belgium, Germany, France, UK)

CE Strategies used: Depolymerization; Industrial Symbiosis

Type of CE innovation: System innovation; ICT innovation

Region(s): Slovenia, Belgium, Germany, France, UK

TRL: 7

What circular challenge / opportunity is the case study trying to address?

RESYNTEX has developed a novel approach to address such some of the challenges of mechanical textiles recycling, using technology to help develop an automated fibre-sorting process with better product results and establishing a large-scale pilot plant to advance chemical textile recycling.

Background of the initiative

RESYNTEX was an €11 million H2020 project that ran between 2015 and 2019. The project sought to accelerate Europe's circular transition, by researching chemical recycling processes for textiles (Botha, 2021). It did this by designing, developing and demonstrating environmentally impactful industrial symbiosis between unwearable textile waste and the chemical and textile industries. The project comprised (RESYNTEX, 2017):

- A strategic re-design of the whole value chain from textile waste collection up to new marketable feedstock for chemical & textile industries
- Creating tools to increase public non-wearable textiles collection for recycling, which would be used as feedstock by the project
- Developing and implementing a data aggregation system to ensure waste traceability and provide relevant data for economic and environmental assessment.
- Developing new business models adapted for commercial opportunities identified. A combination of LCA and LCC helped to identify higher-impact and cost-effective recycling routes (CORDIS, 2021).
- Piloting a demonstration process based on a synergistic chemical and biotechnological cascading separation/transformation approach of textiles' basic components (proteins, cellulose, polyamide and polyester) from textile blends as basic feedstock materials for chemical & textile industries.
- The technology used sorted fibres by composition and was complemented by the use of near-infrared spectroscopy technology.

Impact and maturity of the initiative

The project successfully demonstrated an automated fibre-sorting technology that yields approximately 85% clean textile material of very high purity (99 %) (RESYNTEX, 2019). The pilot plant in Slovenia is still up and running, and recycles c. 100 tonnes of textiles waste per year, transforming it into secondary raw materials, such as bioethanol, for the chemical and textile industries, creating circularity and reducing environmental impacts ([CORDIS, 2021](#)). Consortium

members continue to investigate how they can scale up the most promising chemical hydrolysis methods for obtaining new raw materials such as biodegradable plastics ([CORDIS, 2021](#)). While chemical recycling is new and large-scale recycling is still being developed, elsewhere a number of industry operators are now commercialising the technology including: [Worn Again Technologies \(UK\)](#); SaXcell (NL); and [Renewcell \(SE\)](#).

Section 3 - What's Needed to Circularise Ireland's Fashion and Textiles Sector?

The examples case studied for this Guide range in maturity and technological readiness level from earlier-stage pilots (with Technology Readiness Levels 7 or 8), such as the Resortecs and RESYNTEX projects, or more mature, fully commercialised circular fashion and textile innovations and products, such as Teemill and Nudie Jeans Co (TRL 9). All twelve of the case studies presented here reflect important aspects of circular economy related to the fashion and textiles sector – from circular materials, resources and inputs; circular manufacturing processes; circular business models innovations; and different end-of-use circular strategies.

In this section we draw out some of the key lessons learnt about what's needed to pilot and scale effective circular fashion and textiles innovations, based on our analysis of the case studies. We highlight some of the key barriers to building a broader ecosystem that sustains and supports circularity. Subsequently, we present two regional examples recognised as being pioneers in supporting circular fashion and textiles. Finally, based on our cross-comparative analysis of these regional examples, and the wider literature, we conclude with five key recommendations which aim to advance circularity in Ireland's Fashion and Textiles Sector.

Key Enablers/Lessons Learnt from the Case Studies and Wider Literature

While the means by which they do so varies considerably, an effort to minimise waste and reduce resource consumption in the fashion and textile sector is a theme that cuts across the case studies profiled for this Guide. Despite the variations between them, cross comparative analysis of the case studies reveals a number of important cross-cutting lessons that can apply to the Irish context, and our efforts to support the transition to a fully circular fashion and textiles economy. Some of these key lessons include:

1. **Taking action:** For Fashion & Textiles industry operators a critical first step to embarking on your business's transition to a circular economy is to identify small but measurable changes where your company can concentrate its efforts. The resources section of this Guide includes some helpful resources to get you started. Moreover, new professional training courses, such Circular by Design, a CIRCULÉIRE-supported pilot led by Creative Futures Academy, NCAD and DCCI, are looking to offered tailored training and support for textile and apparel designers, brands and manufacturers to make the transition to circular practises in every step of their design practice, value chain and business model ([CFA, 2022](#)).

2. **Adopting a culture of iterative Research and Innovation in the company:** A success factor for many of the circular fashion and textiles companies profiled for this guide underscores the need to embed and foster a culture of sustained research and development around circular innovations. Such an approach has been key to the Mi Terro's approach to developing and testing yarn prototypes made from spoiled milk. The first version of their milk-to-textile process took two months to complete, and the team have been working to improve their fabric ever since. They have been developing a second fibre which is blended with viscose which has its own natural properties that will help it to boost the performance of their fibre and make it cheaper than organic cotton or modal (MEDA, 2021). Meanwhile, DyeCoo in Netherlands, spent more than 10 years of research and innovation to develop their own technology for replacing water with CO₂ for the dyeing process (ECESP, 2016a). Here research partnerships – such as through innovation vouchers and grant funding - with academic institutions and RPOs can play a critical role in initiating research-led innovations.

3. **Find appropriate Financing and Support to initiate Circular textile and fashion activities:** Where financial support is being sought to finance a fashion and textile company's circular innovation project, consideration should be given to its Technology Readiness Level (TRL). The maturity of the solution, and proximity to market is likely to have a bearing on where appropriate financing can be sought. The case studies profiled here illustrate the value of engaging with EU R&I programmes, such as Horizon Europe and LIFE, to de-risk and finance circular activities in the fashion and textiles sector with a lower TRL, and which may struggle to identify commercial lenders willing to back them. A growing number of financial supports and initiatives can be accessed by established fashion and textiles SMEs and enterprises to support them on their circular economy journeys – like Enterprise Ireland's [Climate Enterprise Action Fund](#) and [Disruptive Technologies Innovation Fund](#), EPA's [Green Enterprise Innovation Fund](#) and SFI's National [Challenge-based Funds](#). Meanwhile, grant funds that require value chain collaborations can also help to put the framework conditions in place for systems-level innovations (e.g. by incentivising collaboration between different parts of the Fashion and Textiles value chain that might otherwise struggle to collaborate around shared circular economy goals). In addition to EU funding programmes, private sector financiers (such as commercial banks and investors) also play an important role in funding circular activities in the textile and fashion sector. While access to capital remains a challenge for circular businesses, there are signals that investors and lenders are becoming more aware of the economic opportunity and improved environmental and societal outcomes that circular businesses and ventures present. Solutions case studied in the Guide, such as Spinnova, have received private funding to develop their solution, and have benefited from participating in sector-focused accelerators like the Amsterdam-based [Fashion for Good Accelerator](#), which is open to international textile value chain

industry operators. Meanwhile, [CircularInnoBooster Fashion and Textile \(F&T\)](#) is an EU COSME project that aims to transform companies in the fashion and textile industry into sustainable, circular, and regenerative ones. For the two years the project runs, SME-led transnational projects can avail of direct funding of €12,000.00 and other supports to create a new innovative product, process, service or business model. While not specific to the fashion and textiles sector, [CIRCULÉIRE's](#) new venture programme, delivered in collaboration with [Tangent, Trinity's Ideas Space](#), is the first of its kind in Ireland (established in 2020) to target late-stage ventures who are demonstrating or enabling circular business models. Successful awardees receive a grant of €5k each and participate in the [New Venture Innovation & Mentoring Programme](#). Meanwhile in 2021, [Bord na Móna](#) launched [Accelerate Green](#) - a green innovation accelerator programme.

4. **Circular fashion and apparel businesses require a re-thinking of traditional customer relationships:** Circular fashion and apparel companies are rethinking how they interact with their customers, promoting a more collaborative, environmentally conscious relationship from traditional linear businesses. Such businesses are taking greater responsibility for the products (and waste they put on the market) and are looking at how they can extend their products' lifespans through repair and re-selling activities. Teemill enables its customers to make use of its technology platform, and has a multiplier effect, by enabling other brands to better report their carbon reduction and waste reduction impacts (Teemill, 2021). Meanwhile, Nudie's customer relationship doesn't just stop once it has sold a customer a garment – instead it helps its customers tackle issues of overconsumption (a major challenge in fashion) by supporting reuse and repair through its platform (Warren, 2021). Meanwhile, Circos' rental subscription model tackles textile waste associated with baby clothing by having customers lease and return rather than outright purchase its range of high-quality clothing from different brands (EMF, 2019). Meanwhile, retailers, like Brown Thomas, are forging strategic partnerships with repair specialists which present opportunities to change traditional customer relationships in the service of extending the lifespan of luxury products. Rethinking an apparel companies' relationship to customers, such as by adopting a service flip to a Product-as-a-Service model unlocks new opportunities for circular business model innovations.
5. **Recognise the increasingly important role of technology and digitalisation:** Fashion and Textile industry operators must recognise the increasingly important role that technology and digitalisation will play in promoting collaboration, and data gathering and sharing between value chain stakeholders around circular supply chains, product traceability and circularity performance. thredUP has initiated a buy back scheme for old clothes from any brand in US through an online platform (EMF, 2009). Teemill has initiated a traceable supply chain and supports its closed loop recycling through its open

access, circular supply chain platform (EMF, 2020a). Furthermore, DressX uses virtual 3D rendered dresses to provide a solution for social media content creation without the need for physical products for example clothing (EMF, 2020b). These case studies demonstrate how sharing platform technology can play an enabling role in circularising textile value chains. Linked to the SPI and EU Strategy for Sustainable and Circular Textiles, a digital product passport for textiles is expected to be introduced based on mandatory information requirements on circularity and other key environmental aspects.

Key Barriers in transitioning to a Circular Economy

Based on the authors' analysis of the literature and case studies, several cross-cutting issues are identified which pose a considerable obstacle to transitioning from a linear to circular economy for the fashion and textiles sector. These issues, which are outlined below, offer important insights for Irish policymakers and industry stakeholders with an ambition to circularise Ireland's domestic textile ecosystem:

1. Ireland is at the end of a long global distribution chain

Section One noted that Ireland's once-thriving indigenous textiles industry has steadily declined since the 1990s. Manufacturing has largely been offshored to developing and emerging economies (Keane et al., 2008). Ireland today is a net importer of clothing and textiles, much of which today is cheaper, fast-fashion garments. This reality that Ireland is at the end of a long global distribution chain must be front and centre when looking at how the sector can be circularised now and in the future. It suggests that second-life enablers, and fashion and apparel retailers will need to play an important role, particularly in exploring opportunities to valorise post-consumer textile waste at scale. Globally, the apparel ecosystem is fragmented, with no single player accounting for more than 1 percent of the market (McKinsey & Company, 2021). This is significant as transitioning towards circular value cycles and business models across the value chain requires a pre-competitive space where different fashion and textiles ecosystem stakeholders can collaborate and test new models (Global Fashion Agenda, 2021). Presently, there are insufficient incentives for value chain collaboration between actors. Other barriers to circular economy are found in relation to the role individual companies play in a value chain as well as to the dominating logic of how they sell and distribute their goods to the market (Ritzén and Sandström, 2017). In this regard, three areas are identified beyond post-production recycling that are critical to supporting pre-competitive action: standardized consumer labelling, infrastructure for collection and sorting, and shared logistics (Global Fashion Agenda, 2021).

2. Circular Fashion and Textile businesses will remain niche in a linear economy

Undoubtedly the case studies demonstrate that circular business models, have the potential to create value during the use phase and the end-of-use phases of textiles by extending the service life of products and returning textile waste back to economic cycles. Research by the JRC has found that the success of circular businesses in the textile sector is currently limited to a market niche populated by environmentally and socially conscious consumers and social actors committed to sustainable consumption (JRC, 2021). Indeed, the study finds that as long as the economic framework favours a linear growth model, “circular enterprises are restrained from gaining traction in the textile market” (*Ibid.*). An explanation offered for this is that in a linear economy, environmental and social costs are usually externalised – this allows for low-cost and short-lived clothing to be offered on the mass market. Whereas circular business models tend to higher degree of cost internalisation (e.g. domestic labour costs), which puts them at a competitive disadvantage. Furthermore, compared to the price of recycled fibres, the market price for virgin textile fibres is low (Elander & Ljungkvist, 2016).

3. Overconsumption remains a barrier to circular fashion and textiles

While the second-hand shop trend is gaining popularity among the younger generation (SICURELLA, 2021), research commissioned by the EPA has found that per capita consumption of new textiles in Ireland was estimated at 53 kg per person in 2019 - an amount which increased from the previous year ([EPA, 2021](#)). This suggests that while some consumers may support more conscientious consumption, on the whole clothing and textile consumption remains on the rise nationally. Indeed other factors are contributing to slower uptake of sustainable consumption behaviours - such as availability, affordability, convenience, product performance, conflicting priorities (WBCSD, 2008). Additionally, there is a lack of incentives to change consumption habits and promote concepts of sharing, leasing, re-using or wearing garments for a longer period. Circular economy is still predominantly understood as recycling which at times even has a negative connotation for some consumers. This may be due to a perception that recycled clothes are of lower quality and durability; that recycled clothes do not justify additional expense, or that the environmental claims associated with recycled clothes are unsubstantiated (JRC, 2021). In spite of some shifts towards Peer-to-Peer apparel resale, missing knowledge on recycling strategies and materials (e.g. use of mono-fibres versus mixed fibres) are also barriers for customers to adopt more circular consumption practices (BMZ, 2017).

4. Externalisation of costs, underdeveloped infrastructure for separate collection and recycling, textile exports and lack of funding

There are a wide range of macro-economic barriers that inhibit the adoption of circularity in the textile industry. In principle, using recycled fibres is more costly than using virgin materials. This can be attributed to the lack of internalisation of external costs of virgin fibre production – even though recycling and reuse largely entail a wide range of environmental benefits. These can include lower greenhouse gas emissions, decreased energy consumption, mitigated use of fertilisers,

pesticides, dyestuffs etc. However, to date the associated economic costs are not borne by manufacturers or fashion brands. In addition, competitive markets hinder a rapid transformation because the separation of mixed fibres is too costly and recycling technologies are not (yet) producing textiles of equivalent quality and performance at scale.

In order to tackle the growing amounts of textile waste effectively, efforts must be made to put fast fashion out of fashion and to change consumer behaviour around fashion. Meanwhile, there is a clear need to invest in improving the infrastructure for collecting, sorting and recycling post-consumer textiles waste. and recycling needs to be developed. Regarding the end-of-use phase of textiles, there is a need for an entire new sector of collecting and restoring post-consumer goods, re-designing/re-producing garments, and to set up value chain collaboration between brands, waste companies and recyclers.

The EPA-backed [Circular Textiles initiative](#) involves piloting three different separate collection systems for used textiles on the Irish market– such as kerbside collections, or new collection points – to test out their impacts (CRNI, 2021). Funded through the EPA's Green Enterprise Innovation Fund, the three pilots, Donate Don't Waste, are taking place in [Arklow Co Wicklow](#), [Buncrana Co Donegal](#) and [Charleville Co Cork](#) and will be completed in 2022.

5. Insufficient Data and failure to integrate Circular Design principles into production processes contributes to poor circularity outcomes

The shift towards fast fashion has resulted in ever-higher quantities of low-quality textile waste, making it unfeasible to recycle or resell at an economic margin (Koszevska, 2018). Considerable challenges remain in scaling up recycling technologies to the levels needed. Operationally, the separation process is often considered tedious due to the complex and blended fibre composition of the textile waste, which makes it difficult to extract the desired component. The extent of recycling ability also depends on the quality of the textile product, its degree of wear, physical condition and the presence of accessories on it such as buttons, logos, labelling etc. Decisions made during the design stage of apparel, influence the circular economy model to a greater extent (Earley, 2020). Based on the design of the product, specifications like colour, material usage, manufacturing method, and finishing will be finalised. To increase the product quality and durability, harsh chemicals and different blends of fibres are used which often do not meet the sustainable clothing requirements. Across Europe, a lack of data and lack of reporting requirement on the circularity status and treatment of post-consumer textiles and on the overall fibre composition of non-reusable textile waste is inhibiting the ability to set policy targets and measures to increase circularity (JRC, 2021). Meanwhile this has a knock effect in contributing to limited planning reliability for investments in textile recycling and technological innovation (*Ibid.*).

Finally, research undertaken by the JRC has highlighted the uneasy interdependencies between the linear and circular economy:

“[A] garment refurbishment business can do well in a linear economic environment because the market offers access to almost unlimited and low-cost feedstock of old textiles. In a circular economy, the amount of discarded post-consumer clothing would be much lower, depriving the refurbishment business of an important commodity.”

Building an Environment for Circular Economy in Ireland’s Fashion and Textiles Sector

Our research finds that while there is top-level support for sustainable, circular fashion to develop in Ireland, to date, most circular fashion and textiles activity operates in the social rather than commercial sectors and is predominantly focused on reuse and recycling of post-consumer waste – rather than at the earlier design phases of textile and apparel production. Based on the availability of agricultural and bio waste in Ireland, our research suggests there are considerable opportunities to replicate and advance circular bioeconomy innovations to produce sustainable bio-materials for the textiles sector (like the Mi Terro and Spinnova case studies profiled in this Guide). If developed in an environmentally conscious way, these biodegradable, renewable and circular fibres have the potential to support the circular transition of the sector whilst increasing the resource efficiency and sustainability of the agriculture and forestry sectors in the country.

Our desktop review of international frontrunners that are blazing a trail in advancing a Circular Fashion and Textiles sector highlights the central role that government is playing in encouraging industry-led collaboration and innovation. Below we present two short case study examples (The Netherlands and Finland) which offer a blueprint of how policymakers can create a supportive environment wherein circular innovations can flourish:

The Netherlands:

Since 2016, the Netherlands has been mapping ways to achieve a fully circular economy by 2050. The Dutch government convened private stakeholders, civil society and academic institutions to create a roadmap to move the Netherlands toward a fully circular economy, while also delivering a 50% reduction in the use of primary raw materials by 2030. Five transition agendas were identified, and specific actions were appointed to key industry sectors and value chains. The Transition Agenda for Consumer Goods, published in 2018, is especially relevant for textile and fashion sector, as it explicitly outlines the main steps for moving towards a circular textile and fashion sector value chain. Together with Furniture and Electrical Appliances, change in the textile and fashion sector is expected to contribute substantially to the government's overall circular goal. In 2020, the Dutch Circularity Gap Report found that the Netherlands was already 24.5% circular—higher than many of its European counterparts (CarronE et al., 2021). The Dutch

Circular Economy Plan focus mainly in three aspects comprising (i) Reduce: changing consumption patterns and fostering circularity, (ii) Reuse: prioritizing clothing reuse locally, and (iii) Recycling: scaling recycling and local fibre processing (Holland Circular Hotspot, 2020).

Finland:

Finland was one of the first countries in the world to develop a nationwide circular economy plan in 2016, under the guidance of the Finnish Innovation Fund Sitra (Studies, 2016). This roadmap outlined a strategy for transitioning the country away from a linear economy based on "make-take-dispose" to one that protects resources and eliminates waste along value chains. Transitioning to a circular economy is estimated to create at least €1.5 – 2.5 billion growth potential per year for the Finnish economy (Kämäräinen, 2020). It has been estimated that 44 % of end-of-life textiles from households are already separately collected. The separate collection is already expanding step by step and becoming nation-wide by 2023. Investment decisions for providing sorting facilities and recycling technologies have been successfully made based on the current regulation. The Finnish State is taking a lead role in advancing its circular fashion and textiles economy ambitions. In 2021, Business Finland (the national business support agency) granted waste management company, Lounais-Suomen Jätehuolto (LSJH), circular economy investment aid of €5.2 million to build a full-scale end-of-life textile refinement plant in Topinpuisto in Turku.

When the plant is ready, Finland will be the first country in the world where post-consumer textiles are obtained nationwide for reuse and recycling. The refinement plant is estimated to employ approximately 100 people by 2025, while it is estimated that the domestic textile ecosystem could create as many as 17,000 new jobs in Finland (Lounais-Suomen Jätehuolto, 2022).

Five Key Recommendations to Advance Ireland's Circular Fashion and Textiles Sector

From the wider literature and case studies, a number of key measures are identified which can play an important role in supporting the development of a circular fashion and textiles ecosystem. We present them below with consideration for how they might be applied to supporting this goal in the Irish context:

a. Initiate Education and Awareness Campaigns About How to Reduce Over-Consumption and Prevent Post-Consumer Textile Waste

As is noted in the WAPCE, our research underscores the need for Government to support an education and awareness campaign around textiles as a theme of SDG 12 Sustainable Production and Consumption (DECC, 2020). Similar efforts were undertaken in the Netherlands as part of its Circular Textile Economy Transition Agenda, to raise awareness among industry and other target audiences (e.g., public consumers), about promoting circular textile products and materials, and highlighting circular textile innovation pilot successes (Köhler et al., 2021).

Importantly any consumer education and awareness campaigns must take prevention as their starting point, and recognise that less consumption of clothing, and care and repair of clothing will be critical to stemming the current challenges of a linear (and fast) fashion and textiles economy. Meanwhile alternative circular business models should be promoted and supported – exploring how clothes swap and rental services, such as the [Nu Wardrobe](#) (IE) or [Uniform Reuse \(UK\)](#) or fashion libraries found elsewhere – like NYPL (US) or [LENA](#) (NL), can be mainstreamed and easily accessed.

Producers have an important role to play in taking greater responsibility of their products along the value chain, including at the point they become waste ([EC, 2022](#)). While key changes in European regulations, such as those linked to the Sustainable Products Initiative, will mandate such changes for industry, industry can take proactive measures to ready themselves for a circular fashion and textiles economy, by encouraging consumers to buy recycled and/or sustainable, higher-quality materials, ensuring consumers are given proper care guidance to make products last longer, and importantly, accepting clothes back into the value cycle at the end of their life (Global Fashion Agenda, 2021). Apparel producers and retailers can also help to close the loop on post-consumer textile waste by ensuring there are services to facilitate these items' repair, recycling or repurposing at their end of use (see Brown Thomas's collaboration with [The Restory](#) for an example of this). Moreover, efforts to standardise and implement consumer-facing eco-labels, such as [Nordic Swan](#), can play a role in making the information about textile products' circular credentials more accessible to consumers too. Following a public consultation, eco-label, Nordic Swan, has included new criteria to makes its eco-label more aligned with the goals of a circular economy. This includes new requirements for both brand owner and textile manufacturer that unsold textiles must not be sent for incineration or landfill ([JRC, 2021](#)).

b. Cross-Sectoral Collaboration for Circular Economy

Collaboration and coordination between key parts of the textiles value chain is key. Creating the conditions where a circular fashion and textiles sector can develop requires a coordinated ecosystem of actors with a shared understanding and future vision for the sector work in concert to drive system change (Global Fashion Agenda, 2021). Effectively prototyping, commercialising, and scaling up proven circular fashion and textile innovation requires far more effective value chain cooperation, collaboration, and joint experimentation. The recognition that insufficient incentives exist for value chain actors to work in this way is one of the reasons why networks such as the [Fashion for Good Innovation Platform](#) work to convene and bring the entire fashion ecosystem together.

While industry alliances and innovation programmes can go some way in creating the conditions for such value chain cooperation, the government can also play a critical role as convener and innovation broker in support of this goal of joining up the value chain. Importantly, on-the-ground coordination is needed with input by

local stakeholders to establish relationships and practices for successful waste collection and segregation with textile producers, manufacturers, and waste collectors and others (*Ibid.*). Creating a conducive environment for circular fashion and textiles, requires engaging and empowering industry players so that a unified industry voice be presented on the wider transition needs, risks and challenges facing the sector. An inclusive, multistakeholder model must be therefore adopted to:

- **Engage with key operators across the textiles value chain to co-design transition pathways and deep demonstrators to achieve a net-zero carbon circular economy for the island of Ireland.** Such an approach should aim to provide best-in-class thought leadership and guidance to industry about best practices, to assess transition infrastructure needs, and to co-define high priority deep demonstrator pilots with potential to advance a circular fashion and textile sector for Ireland.
- **Highlight forthcoming circular economy policy and regulatory changes to industry in a timely manner linked to the industry's Transition Agenda.** The forthcoming EU Textiles Strategy, for instance, is expected to include measures which aim to boost textile sorting, re-use and recycling, through innovation and other means, and encourage industrial applications and regulatory measures such as extended producer responsibility (EC, 2021b). It is expected to support separate textile waste collection by 2025. Others, such as those linked to the Sustainable Products Initiative, are expected to place additional minimum ecodesign requirements on textiles producers. Industry should be actively engaged with to ensure they are ready to adapt to the raft of regulatory changes such as these, ensuring that feedback to ensure the successful adoption of such policy changes is done in a timely and inclusive manner.
- **Share circular innovation success stories.** Such a forum should seek to promote the benefits and success stories of industry operators who are already initiating efforts to scale recycling, repair and reuse capabilities within the fashion and textiles sector

c. Implement Policy Innovations that align with the goal of circularizing the Fashion and Textiles Sector.

Policy, regulations and legislation all have a considerable bearing or supporting or inhibiting circular market conditions. A number of precedents demonstrate how Government can implement different policy and legislative levers to stimulate circular fashion and textiles both upstream and downstream. France, for instance, implemented a law in 2019 banning the destruction of unsold clothing. This is something which the forthcoming Sustainable Products Initiative looks set to implement across Europe, placing additional requirements that European textile products are more durable, reusable, repairable, recyclable (EC, 2021b). Other commentators, such as Mizrachi et al. (2022), propose innovative regulatory methods be employed. Following the precedent of marketing restrictions and packaging warning labels for tobacco and alcohol products, they have called for

stricter advertising standards for the apparel industry. This, they suggest could restrict the publication and/or require clarification of risks or production shortcomings, particularly of “fast fashion”, as a way to contribute to consumer and producer awareness about its environmental and social implications (Mizrachi and Tal, 2022). Meanwhile, taxation and levies could also be used to circularise the fashion and textiles market. In an effort to grow its repair economy, Sweden has instituted reduced VAT on repair activities undertaken on household items like clothing. Meanwhile, higher tax rates could also be levied on less sustainable and circular fashion products (Mizrachi and Tal, 2022), to increase first mover and competitive advantages for fashion firms that actively working to be more circular and sustainable. Such efforts would support the objectives of the WAPCE by reducing the cost differential of higher value indigenous producers.

d. Ensuring Funding and Investment is Directed Strategically Towards Building an Ecosystem that Facilitates Circular Fashion and Textiles

Several case studies demonstrate the critical role that European and national grant funding programmes play in stimulating circular innovation in the sector. At the national level, circular innovation funding instruments like the DECC's Circular Economy Innovation Grant Scheme and the EPA's Green Enterprise Innovation Fund, have both played a role in supporting circular textile pilot programmes.

However, while a steady number of grant funding, and financial and non-financial support instruments are coming on stream, there is a risk that without a strategic and cross-cutting funding and investment agenda to frame the sector's infrastructure current and future investment needs, funded projects are at risk of being ad hoc and piecemeal. Recent development, like Slovenia's [national Financing the Circular Transition programme](#), illustrates the value of looking to align and close the gap between grant funding architecture and investment capital around identified strategic transition goals that require financing.

A lack of financial incentives continues to be a significant transition risk in growing the circular fashion and textile industry. This is one of the main reasons why the Dutch Circular Textile Economy Transition Agenda intends to build a market and infrastructure for circular textile goods and materials as one of its primary objectives (Daño et al., 2020). Here, the establishment of circular fashion and textiles incubators and accelerators can and do play a part in building a steady pipeline of new circular fashion and textiles ventures too. Importantly, and in line with forthcoming activities looking to improve the circularity of Ireland's textiles ecosystem as part of the WAPCE, there is a need to create funding and supports that in addition to supporting individual companies look to strategically address systemic gaps or market failures in the current system. Related to this point, the role that Business Finland has played in being a “investor of first resort” (Mazzucato, 2011) in developing the country's national textiles recycling infrastructure offers an interesting precedent that could be emulated in the Irish context, should the need and feasibility of doing so be established.

e. Develop Key Players' Competencies and Skills

Creating a circular fashion and textile ecosystem will require that a new generation of textile professionals spanning all phases of the textile product lifecycle are given the necessary skills and training to embrace circular design principles. New education and training programmes must be designed to satisfy the unique learning, knowledge, skills, and capacity development needs of key players in the value chain to realise the promise of circular fashion and textiles. Designers and Fashion Buyers, for instance, must be supported to be reskilled in circular design and sustainability as a way to stimulate circular economy innovation at different points in the value chain.

Meanwhile other actors within the value chain, such as waste management companies, must be engaged with to ensure that necessary technology, infrastructure and collection and sorting facilities are developed to support circular textile needs. Adopting a holistic approach to growing Ireland's circular textile capabilities thus necessitates the creation of specialised circular fashion and textile courses as well as ensuring circularity and sustainability is integrated into conventional fashion design and merchandising degrees and courses.

In late 2021, CIRCULÉIRE member Design and Crafts Council of Ireland was awarded grant funding through the programme's dedicated Circular Innovation Fund to develop '[Circular by Design](#)' - a first-of-its-kind pilot circular design training programme targeted at Irish fashion and textiles industry players. The training programme was developed jointly by DCCL, the Creative Futures Academy and NCAD and has been rolled in 2022.

Resources and Tools

- Circle Lab's Knowledge Hub has industry-focused reports, case studies and research about the Fashion and Textiles sector: <https://knowledge-hub.circle-lab.com/frameworks/5/99>
- Fashion for Good's Sustainable Brand toolkit includes a number of circular economy resources and guides to help textile and fashion consumers get started on their circular economy journey: <https://fashionforgood.com/brand-tool-kit/>
- Nordic Swan Ecolabel (an ecolabel which has already set out to align itself with circular economy outcomes) has created helpful resources online to guide textile producers about criteria, costs, regulations, marketing and graphical guidelines needed to get started with an application: <https://www.nordic-ecolabel.org/certification/>
- OVAM (the Public Waste Agency in the region of Flanders, Belgium) has developed a practical guide for Circular Textiles Professionals: https://www.nweurope.eu/media/12491/2020_guide-circular-professional-textiles_eng.pdf
- Professional training: Circular by Design for Textiles and Apparel Industries <https://creativefuturesacademy.ie/courses/circular-by-design-for-fashion-and-textiles/>
- The Cradle to Cradle Product Innovation Institute has developed an advanced series of methods for designers, entrepreneurs, and innovators to ensure their material choices integrate safe and circular principles from the very start: <https://www.c2ccertified.org/education/safe-circular-material-choices>
- The Ellen MacArthur Foundation has compiled a range of resources and tools for fashion businesses: <https://ellenmacarthurfoundation.org/topics/fashion/overview>
- The Sustainable Apparel Coalition has developed the Higg Index, a suite of tools, including the Higg Materials Sustainability Index (MSI), that standardizes value chain sustainability measurements for all industry participants. These tools measure environmental and social labour impacts across the value chain. With this data, the industry can identify hotspots, continuously improve sustainability performance, and achieve the environmental and social transparency consumers are demanding: <https://apparelcoalition.org/higg-product-tools/>
- Thredup has developed a user-friendly 'Fashion Footprint Calculator' to help consumers easily understand the environmental implication of the fashion consumption behaviours - <https://www.thredup.com/fashionfootprint/>

References

- Accelerating the Circular Economy (PACE), 2021. Accelerating the Circular Economy (PACE).
- Ammar, R., 2019. LCA speaks louder than the Ecolabelling.
- Blum, N.U., Haupt, M., Bening, C.R., 2020. Why “Circular” doesn’t always mean “Sustainable.” *Resour. Conserv. Recycl.* 162, 105042. <https://doi.org/10.1016/j.resconrec.2020.105042>
- Botha, S., 2021. RESYNTEX: innovation in textile recycling [WWW Document]. URL <https://knowledge-hub.circle-lab.com/AfricanCAT/article/9095?n=RESYNTEX-innovation-in-textile-recycling> (accessed 8.24.22).
- CarronE, N.P., Lagunes, L.S., Duijn, H. Van, Wilting, J., Novak, M., Metta, J., Goesaert, T., Bachus, K., 2021. Putting circular textiles to work | The employment potential of circular clothing in the Netherlands.
- Centre for Sustainable Fashion, 2019. Support Report Mapping Sustainable Fashion Opportunities for SMES. Brussels, Belgium.
- CFS, 2020. YEAR ZERO - Circular Fashion Report 2020.
- Christis, M., Vercauteren, A., Arnold, M., Nicolau, M., Lafond, E., 2019. Textiles and the environment in a circular economy, European Environment Information and Observation Network (Eionet).
- Chybová, O., 2017. Report on wastewater handling in the textile industry in Europe. Czech Republic.
- Circoax, 2022. Circular InnoBooster [WWW Document]. URL <https://circoax.eu/> (accessed 1.21.22).
- Circulary, 2019. DyeCoo’s water-free and process-chemical free-dyeing technology for textiles [WWW Document]. URL <http://www.circulary.eu/project/dyecoo/> (accessed 1.10.22).
- Connolly, L., McIntyre, B., Byrne, S., Mcevoy, B., Campion, L., 2017. Review of Waste/Resource Exchange Systems and Good Practice Guide. Wexford, Ireland.
- CRNI, 2020. CRNI RESPONSE TO WASTE ACTION PLAN FOR A CIRCULAR ECONOMY. Dublin, Ireland.
- Daňo, F., Drábik, P., Hanuláková, E., 2020. Circular business models in textiles and apparel sector in Slovakia. *Cent. Eur. Bus. Rev.* 9, 1–19. <https://doi.org/10.18267/J.CEBR.226>
- Dept. of Communications Climate Action and Environment, 2019. A Waste Action Plan for a Circular Economy | Ireland’s National Waste Policy 2020-2025, Government of Ireland. Dublin.
- Earley, R., 2020. Upcycling, design and material innovation.
- EC, 2021a. EU strategy for textiles. Brussels European Council.
- EC, 2021b. Sustainable products initiative [WWW Document]. URL https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative_en (accessed 1.21.22).
- ECAP, 2019. ECAP and used textiles.
- EEB, 2021. Sustainable product policy initiative.
- Ellen Macarthur foundation, 2017a. FASHION AND THE CIRCULAR ECONOMY [WWW Document]. URL <https://archive.ellenmacarthurfoundation.org/explore/fashion-and-the-circular-economy> (accessed 1.18.22).

- Ellen MacArthur foundation, 2017b. A New Textiles Economy: Redesigning fashion's future.
- Ellen MacArthur foundation, 2015. Circularity Indicators: An approach to Measuring Circularity.
- Ellen MacArthur Foundation, 2020a. An open access, circular supply chain for t-shirts: Teemill [WWW Document]. URL <https://ellenmacarthurfoundation.org/circular-examples/an-open-access-circular-supply-chain-for-t-shirts-teemill> (accessed 1.10.22).
- Ellen MacArthur Foundation, 2021. A digital-only, multi-brand fashion platform: DRESSX [WWW Document]. URL <https://ellenmacarthurfoundation.org/circular-examples/dressx> (accessed 1.11.22).
- Ellen MacArthur Foundation, 2020c. Circulytics: Definitions List.
- Ellen MacArthur Foundation, 2019. Complete the picture: How the circular economy tackles climate change, Ellen MacArthur Foundation.
- Ellen MacArthur Foundation, 2017. Dissolvable stitches that improve clothing recycling: Resortecs [WWW Document]. URL <https://ellenmacarthurfoundation.org/circular-examples/dissolvable-stitches-that-improve-clothing-recycling-resortecs> (accessed 1.10.22).
- Ellen MacArthur Foundation, 2015. Towards a Circular Economy: Business Rationale for an Accelerated Transition, Ellen MacArthur Foundation (EMF).
- Ellen MacArthur Foundation, 2019. Increasing clothing use through subscription: Circos [WWW Document]. URL <https://ellenmacarthurfoundation.org/circular-examples/increasing-clothing-use-through-subscription-circos> (accessed 1.11.22).
- Ellen MacArthur Foundation, 2016. Enabling brands to capture value from unsellable inventory: The Renewal Workshop [WWW Document]. URL <https://ellenmacarthurfoundation.org/circular-examples/the-renewal-workshop> (accessed 1.11.22).
- Ellen MacArthur Foundation, 2009. Keeping clothing in use to reduce waste: thredUP [WWW Document]. URL <https://ellenmacarthurfoundation.org/circular-examples/keeping-clothing-in-use-to-save-us-money-and-reduce-waste-thredup> (accessed 1.11.22).
- Environment Protection Agency, 2021. THE CIRCULAR ECONOMY PROGRAMME 2021-2027, Environment Protection Agency. <https://doi.org/10.36661/2596-142x.2019vi1i.10902>
- Environmental Protection Agency, 2021. CORPORATE GOVERNANCE FRAMEWORK. Wexford, Ireland.
- EURATEX, 2021. SPINNOVA: THE MOST SUSTAINABLE FIBER AVAILABLE [WWW Document]. URL <https://euratex.eu/stories/spinnova-creates-the-most-sustainable-fiber/> (accessed 1.19.22).
- EURATEX, 2015. EU TEXTILE & FASHION INDUSTRY: FACTS & FIGURES - ANNUAL REPORT 2015. Brussels, Belgium.
- European Circular Economy Stakeholder Platform, 2019. Teemill's circular supply chain: from cotton seed to t-shirt, nothing is wasted! [WWW Document]. URL <https://circulareconomy.europa.eu/platform/en/good-practices/teemills-circular-supply-chain-cotton-seed-t-shirt-nothing-wasted> (accessed 1.19.22).
- European Circular Economy Stakeholder Platform, 2016a. DyeCoo uses reclaimed CO₂ as the dyeing medium, in a closed loop process [WWW Document]. URL <https://circulareconomy.europa.eu/platform/en/good-practices/dyecoo-uses-reclaimed-co2-dyeing-medium-closed-loop-process> (accessed 1.20.22).
- European Circular Economy Stakeholder Platform, 2016b. Infinited Fiber regenerates

- cotton-rich textile waste into brand-new Infinna™ textile fibers [WWW Document]. URL <https://circulareconomy.europa.eu/platform/en/good-practices/infinite-fiber-regenerates-cotton-rich-textile-waste-brand-new-infinnatm-textile-fibers> (accessed 1.20.22).
- European Commission, 2022. EU Strategy for Sustainable and Circular Textiles [WWW Document]. URL <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022DC0141> (accessed 8.19.22).
- European Environmental Agency, 2020. Textiles in Europe's circular economy.
- European Parliament, 2011. REGULATION (EU) No 1007/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on textile fibre names and related labelling and marking of the fibre composition of textile products and repealing Council Directive 73/44/EEC and Directives 96/73/EC and 2008/121.
- Fashion for Good, 2021. ACCELERATOR PROGRAMME [WWW Document]. URL <https://fashionforgood.com/accelerator-programme/> (accessed 1.21.21).
- Fashion United Group, 2022. Fashion Statistics Ireland [WWW Document]. URL <https://fashionunited.ie/statistics/fashion-statistics-ireland> (accessed 8.18.22).
- Francesco, E. Di, Vanhoeck, C., 2021. RESORTECS [WWW Document]. Circ. Conversations. URL <https://www.circularconversations.com/pioneers/resortecs> (accessed 1.10.22).
- Fresh Cuts Clothing, 2021. Fresh Cuts Clothing and MUD Jeans 'Take Back' scheme [WWW Document]. URL <https://www.freshcuts clothing.com/blogs/fresh-cuts-clothing-and-mud-jeans-take-back-scheme/fresh-cuts-clothing-and-mud-jeans-take-back-scheme> (accessed 1.20.21).
- German Federal Ministry for Economic Cooperation and Development (BMZ), 2017. Circular Economy in the Textile Sector, Revista de Quimica e Industria Textil.
- Global Fashion Agenda, 2021. Scaling Circularity.
- Gueye, S., 2021. The trends and trailblazers creating a circular economy for fashion [WWW Document]. Ellen MacArthur Found. URL <https://ellenmacarthurfoundation.org/articles/the-trends-and-trailblazers-creating-a-circular-economy-for-fashion> (accessed 8.19.22).
- Harrison, A., 2021. Don't cry over spilled milk – Mi Terro: from food waste into fabric URL <https://lampoonmagazine.com/blog/2021/08/01/mi-terro-food-waste-clothing-robert-luo/> (accessed 1.19.22).
- Hetherington, A., Malmberg, J., Mariam, S., Munkedal, C., Kilgour, R., Diment, M., 2020. THE CIRCULAR FASHION ECOSYSTEM.
- Holland Circular Hotspot, 2020. From Linear to Circular in the Textile and Apparel Industries.
- ibisworld, 2021. Clothing Manufacturing in Ireland - Market Research Report.
- Infinite Fiber Company, 2021. Infinite Raises EUR 30 million – adidas and BESTSELLER Among New Investors, H&M Group Leads Financing Round.
- Infinite Fiber Company, 2019. Infinite Fiber: New Sustainable Fiber Production Technology [WWW Document]. Circularity. URL <http://www.circularity.eu/project/infinite-fiber-technology/> (accessed 1.11.22).
- Kant, R. (2011). Textile dyeing industry an environmental hazard.
- Kämäräinen, H., 2020. CIRCULAR ECONOMY IN FINLAND: PERCEPTIONS FROM THE TEXTILE INDUSTRY.

- Keane, J., te Velde, D.W., 2008. The role of textile and clothing industries in growth and development strategies, ODI Working Paper.
- Köhler, A., Watson, D., Trzepacz, S., Löw, C., Liu, R., Danneck, J., Konstantas, A., Donatello, S., Faraca, G., 2021. Circular economy perspectives in the EU textile sector. <https://doi.org/10.2760/858144>
- Kokkonen, M., 2021. National Collection of End-of-life Textiles in Finland.
- Len, M., Arditi, S., 2011. The “prepare for reuse” target and the role of Accredited Reuse Centres. Brussels, Belgium.
- Lieber, C., 2018. Why fashion brands destroy billions' worth of their own merchandise every year [WWW Document]. URL <https://www.vox.com/the-goods/2018/9/17/17852294/fashion-brands-burning-merchandise-burberry-nike-h-and-m> (accessed 8.25.22).
- Lounais-Suomen Jätehuolto, 2022. End-of-life textile refinement plant receives funding from Business Finland [WWW Document]. URL <https://www.lsjh.fi/en/end-of-life-textile-refinement-plant-receives-funding-from-business-finland/> (accessed 1.21.21).
- Mazzucato, M., 2011. Wealth Creation and the Entrepreneurial State: building symbiotic public-private partnerships. London, UK.
- McKinsey & Company, 2021. The State of Fashion 2021.
- Metropolitan Economic Development Association (MEDA), 2021. Mi Terro, Femly, Flourish Savings, Options MN, Please Assist Me and Industrack Win Meda Million Dollar Challenge 6 Winners of 3rd Annual Meda Million Dollar Challenge Win a total of \$1,100,000 [WWW Document]. PR newswire. URL <https://www.prnewswire.com/news-releases/mi-terro-femly-flourish-savings-options-mn-please-assist-me-and-industrack-win-meda-million-dollar-challenge-301217065.html> (accessed 1.19.22).
- miterro, 2020. Plastic-Alternative Biomaterials Made From Agricultural Waste [WWW Document]. URL <https://www.miterro.com/>
- Mizrachi, M.P., Tal, A., 2022. Regulation for Promoting Sustainable, Fair and Circular Fashion.
- Nathalie Remy, Eveline Speelman, and S.S., 2016. Style that's sustainable: A new fast-fashion formula.
- NU Wardrobe, 2022. Start swapping today: Sustainable fashion without the price tag [WWW Document]. URL <https://www.thenuwardrobe.com/> (accessed 1.18.22).
- Nudie Jeans, 2019. Nudie Jeans Co: Jeans out of pre-owned jeans [WWW Document]. Circulary. URL <http://www.circulary.eu/project/nudie-jeans/> (accessed 1.11.22).
- O'Leary, E., Tobin, K., Downey, C., Hanlon, E., Miller, S., 2021. Nature and Extent of Post-Consumer Textiles in Ireland Study.
- OECD Publishing, 2021. OECD Environmental Performance Reviews: Ireland 2021, Incentive. Paris, France. <https://doi.org/10.1787/9ef10b4f-en>
- RESYNTEX, 2017. A new circular economy concept: from textile waste towards chemical and textile industries feedstock.
- Ritzén, S., Sandström, G.Ö., 2017. Barriers to the Circular Economy - Integration of Perspectives and Domains. Procedia CIRP 64, 7–12. <https://doi.org/10.1016/j.procir.2017.03.005>
- RTÉ, 2021. Fast fashion leftovers dumped in Chilean desert [WWW Document]. URL <https://www.rte.ie/news/2021/1108/1258514-climate-change-fast-fashion-chile/> (accessed 2.15.22).

- Rudenko, O., 2018. The 2018 Apparel Industry Overproduction Report and Infographic [WWW Document]. ShareCloth. URL <https://sharecloth.com/blog/reports/apparel-overproduction> (accessed 1.19.22).
- Šajn, N., 2019. Environmental impact of the textile and clothing industry: What consumers need to know.
- Sandin, G., Peters, G.M., 2018. Environmental impact of textile reuse and recycling: A review. *J. Clean. Prod.* 184, 353–365. <https://doi.org/10.1016/j.jclepro.2018.02.266>
- SICURELLA, S., 2021. When Second Hand Becomes Vintage: Gen Z Has Made Thrifting A Big Business [WWW Document]. NPR. URL <https://www.npr.org/2021/06/18/1006207991/when-second-hand-becomes-vintage-gen-z-has-made-thrifting-a-big-business?t=1642760390364> (accessed 1.21.22).
- Spinnova, 2018. THIS WOOD-BASED TEXTILE FIBRE IS MADE WITHOUT CHEMICAL SOLVENTS [WWW Document]. URL <https://materialdistrict.com/article/wood-based-textile-fibre/> (accessed 1.19.22).
- SPINNOVA, 2021. Cleanest process. Disruptive circularity [WWW Document]. URL <https://spinnova.com/> (accessed 1.10.22).
- Spinnova Oy, 2019. Spinnova: Bio-based textile fibre [WWW Document]. Circulary. URL <http://www.circulary.eu/project/spinnova-bio-textile-fibre/> (accessed 1.19.22).
- Studies, S., 2016. Leading the cycle: Finnish road map to a circular 2016-2025.
- Teemill, 2021. Circular Organic Clothing [WWW Document]. URL <https://teemill.com/circular-fashion/> (accessed 1.19.22).
- THREDUP, 2021. thredUP Releases Its Ninth Annual Resale Report with First-Ever Impact Section.
- UN Environment Programme, 2020. Sustainability and Circularity in the Textile Value Chain - Global Stocktaking, UN Environment Programme.
- Valuer, 2020. INNOVATION INSIGHT. Copenhagen, Denmark.
- Vertue Lab, 2019. The Renewal Workshop: Impact Case Study.
- WARREN, L., 2021. NUDIE JEANS PLANS TO MAKE 15,000 PAIRS OF JEANS FROM CASTOFFS [WWW Document]. URL <https://sourcingjournal.com/denim/denim-brands/nudie-jeans-tunisia-denim-recycling-unido-switchmed-water-265016/> (accessed 1.20.22).
- Wiener-Bronner, D., 2020. Why dairy farmers across America are dumping their milk [WWW Document]. CNN Bus. URL <https://edition.cnn.com/2020/04/15/business/milk-dumping-coronavirus/index.html>
- Workshop, T.R., 2021. LEADING CIRCULAR 2021: The Climate Crisis, Carbon and Circular.
- World Business Council for Sustainable Development, 2008. Sustainable Consumption Facts and Trends From a business perspective The Business Role Focus Area.
- World Wildlife Fund, 2022. Sustainable Agriculture [WWW Document]. URL <https://www.worldwildlife.org/industries/cotton> (accessed 1.19.22).

DISCLAIMER

Although every effort has been made to ensure the accuracy of the material contained in this Sectoral Guide is complete, accuracy cannot be guaranteed. The author(s) do not accept any responsibility whatsoever for loss or damage occasioned or claimed to have been occasioned, in part or in full, as a consequence of any person acting, or refraining from acting, as a result of a matter contained in this publication. Irish Manufacturing Research do not make any warranty, express or implied, including warranties of merchantability and fitness for a particular purpose, nor does it assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, nor does it represent that its use would not infringe privately owned rights. References in the CIRCULÉIRE's Circular Construction Sectoral Guide to any specific commercial products, process, government policies (both EU and Irish) or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favouring by Irish Manufacturing Research. The views and opinions of authors expressed herein do not necessarily state or reflect those of Irish Manufacturing Research and shall not be used for advertising or product endorsement purposes.
