

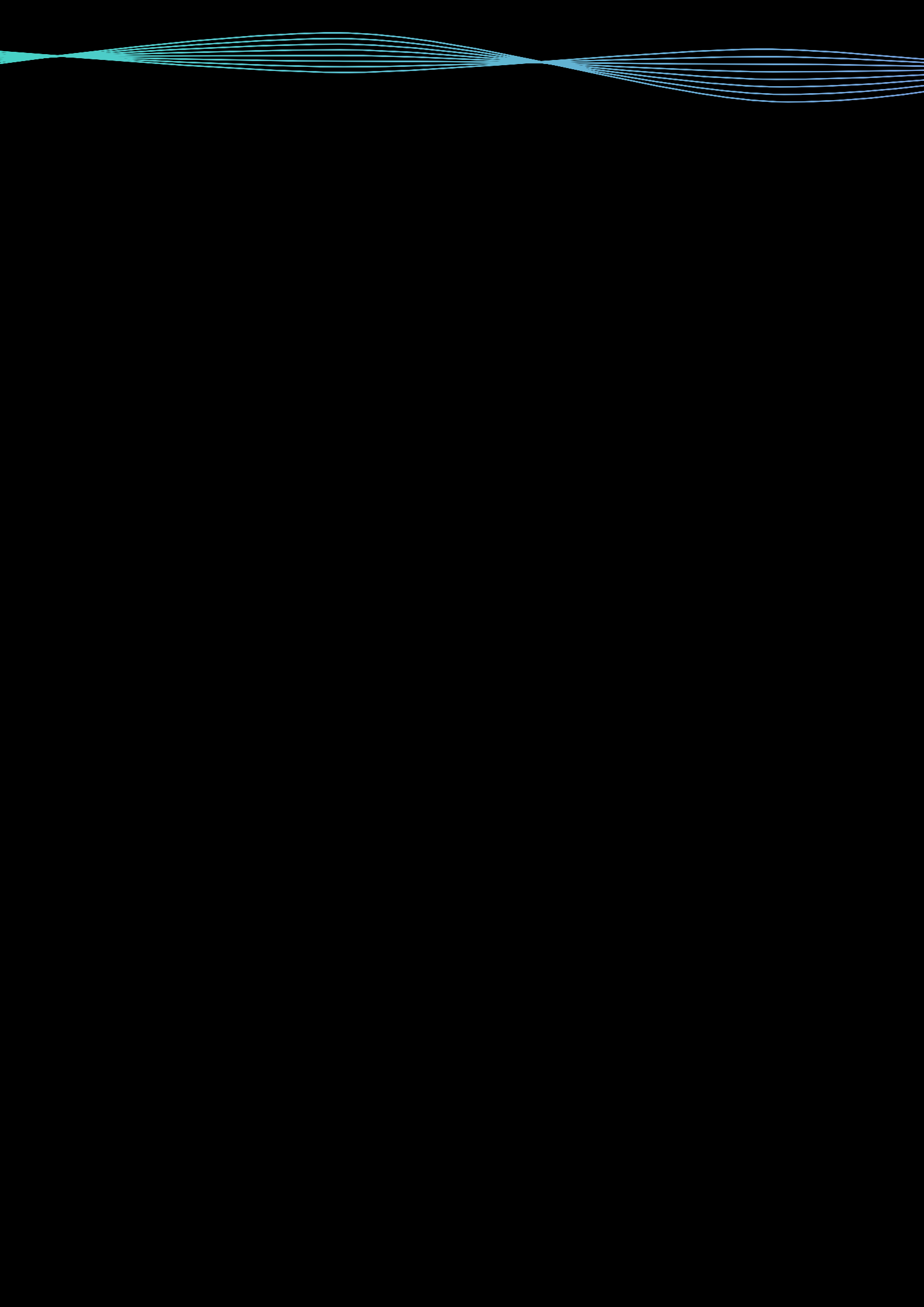
**A NEW TEXTILES ECONOMY:
REDESIGNING FASHION'S FUTURE**



ELLEN
MACARTHUR
FOUNDATION



CIRCULAR
FIBRES
INITIATIVE





EXECUTIVE SUMMARY

It is hard to imagine living in a world without textiles. Nearly everyone, everywhere comes into contact with them nearly all the time. This is especially true of clothing, the focus of this report. Clothes provide comfort and protection, and for many represent an important expression of individuality. The textiles industry is also a significant sector in the global economy, providing employment for hundreds of millions around the world.

These benefits notwithstanding, the way we design, produce, and use clothes has drawbacks that are becoming increasingly clear. The textiles system operates in an almost completely linear way: large amounts of non-renewable resources are extracted to produce clothes that are often used for only a short time, after which the materials are mostly sent to landfill or incinerated. More than USD 500 billion of value is lost every year due to clothing underutilisation and the lack of recycling. Furthermore, this take-make-dispose model has numerous negative environmental and societal impacts. For instance, total greenhouse gas emissions from textiles production, at 1.2 billion tonnes annually, are more than those of all international flights and maritime shipping combined. Hazardous substances affect the health of both textile workers and wearers of clothes, and they escape into the environment. When washed, some garments release plastic microfibrils, of which around half a million tonnes every year contribute to ocean pollution – 16 times more than plastic microbeads from cosmetics. Trends point to these negative impacts rising inexorably, with the potential for catastrophic outcomes in future. This linear system is ripe for disruption.

This report outlines a vision for a system that works, delivering long-term benefits – a new textiles economy based on the principles of a circular economy. It offers a direction of travel on which the industry can agree and focus its efforts. In a new textiles economy, clothes, textiles, and fibres are kept at their highest value during use and re-enter the economy afterwards, never ending up as waste. This vision is distinct from, and complements, ongoing efforts to make the textiles system more sustainable by minimising its negative impacts. With specific emphasis on innovation towards a different system, a new textiles economy presents an opportunity to deliver substantially better economic, societal, and environmental outcomes.

Transforming the industry to usher in a new textiles economy requires system-level change with an unprecedented degree of commitment, collaboration, and innovation. Existing activities focused on sustainability or partial aspects of the circular economy should be complemented by a concerted, global approach that matches the scale of the opportunity. Such an approach would rally key industry players and other stakeholders behind the objective of a new textiles economy, set ambitious joint commitments, kick-start cross-value chain demonstrator projects, and orchestrate and reinforce complementary initiatives. Maximising the potential for success would require establishing a coordinating vehicle that guarantees alignment and the pace of delivery necessary.



IN SUPPORT OF THE REPORT

“This ground-breaking report lays the foundation for a new mindset and creates a shared vision for a circular fashion industry. It’s a call for action for systemic collaborations and is aligned with our efforts in making sure that economic and social development can happen in a way that the planet can afford.”

KARL-JOHAN PERSSON, CHIEF EXECUTIVE OFFICER, H&M GROUP

“Each year more than 18,000 tons of textiles find their way into the City of Phoenix waste and recycling streams. Our city is working on creative solutions to redirect textiles from the waste stream and back into the circular economy as a valuable resource, to ultimately stimulate the local economy. This report puts these efforts in the context of a system-level change that delivers long-term benefits.”

GREG STANTON, MAYOR, CITY OF PHOENIX

“How can we change a wasteful global apparel industry into one that is restorative and regenerative? This is a question that we, at C&A Foundation, are trying to answer. Through our partnership with the Ellen MacArthur Foundation, we are pleased to support this report – an important first step towards aligning the industry on what it takes to build a circular fashion industry.”

LESLIE JOHNSTON, EXECUTIVE DIRECTOR, C&A FOUNDATION

“The Circular Fibres Initiative and the partnership with Ellen MacArthur Foundation intends to bring circular economy to scale in the textile industry. From our experiences, we are convinced of the benefits that circular economy can bring, in both the technical and biological cycles. With our innovative Refibra™ branded lyocell fibres, we are closing the loop on textiles using cotton scraps from the value chain. I sincerely recommend this report as it provides the vision and first steps to make progress towards a regenerative system for fibres.”

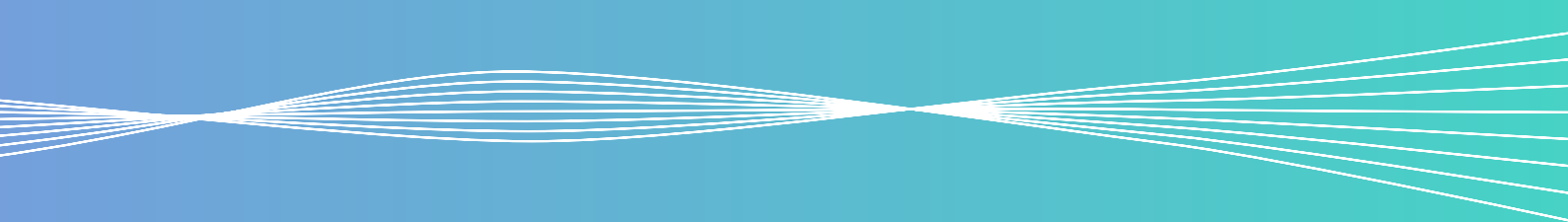
ROBERT VAN DE KERKHOF, CHIEF COMMERCIAL OFFICER, LENZING GROUP

“At Nike, we are pursuing new business models that move away from the take, make, and waste linear models of the past. Our success depends not only on the work within our own value chain, but on disruptive partnerships across a broader textile production and manufacturing ecosystem. This report is an important step in signaling the type of systemic innovation and collaboration required to unlock a future that protects our athletes and the planet while also powering sustainable business growth.”

CYRUS WADIA, VP, SUSTAINABLE BUSINESS & INNOVATION, NIKE, INC

“It is evident that the moment for mainstreaming circularity and changing our consumption and production system is here. There are strong signals and evidence from the science on current and future resource constraints and planetary limits, and growing political and business leadership around the opportunities it offers. This report will surely inspire many success stories, new solutions and practices from all actors which are called to transform the textile value chain”.

TIM KASTEN, DEPUTY DIRECTOR, ECONOMY DIVISION, UN ENVIRONMENT



“This report reimagines the textiles system. New business models, technological innovation, radical collaboration, and most importantly, rapid acceleration are critical steps the report identifies to catalyse this critical transformation.”

JASON KIBBEY, CEO, SUSTAINABLE APPAREL COALITION

“At the Hong Kong Research Institute of Textiles and Apparel (HKRITA) we are very excited about the release of this report. Having seen the issues and challenges of the current fashion and apparel supply chain, we know there is an urgent need for a new model for sustainable production and consumption. Suboptimal production practices, the lack of logistics coordination, and our current linear incomplete business models have resulted in the unnecessary creation of huge volumes of waste, and the shortening of the useful life of materials. We want to understand the facts and participate in the solutions.”

EDWIN KEH, CEO, HONG KONG RESEARCH INSTITUTE OF TEXTILES AND APPAREL

“I believe the circular economy provides unprecedented business opportunities for the fashion sector. The report is a much needed push towards a fundamental shift in industry practices providing the necessary arguments for change, both financially and environmentally. Global Fashion Agenda is excited to further build momentum around the important report recommendations and amplify its messages to a mainstream audience using the convening power of our many wide-reaching platforms, including the Copenhagen Fashion Summit.”

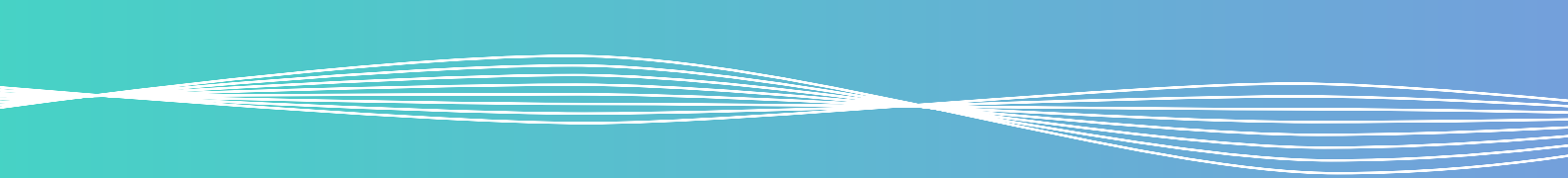
EVA KRUSE, CEO, GLOBAL FASHION AGENDA

“The British Heart Foundation (BHF) welcomes this timely report on clothing impacts and challenges. The BHF’s 560 clothing shops re-use thousands of tonnes a year and, along with the wider charity retail and re-use sector, have a vital role in keeping them in circulation. We also have appetite and capacity to further improve the circularity of textile flows, working with manufacturers, retailers and other partners in this initiative. The charity retail re-use model not only improves the environmental footprint of textiles, it creates social and economic resilience through employment, volunteer opportunities and supply of affordable goods, whilst raising millions of pounds for good causes. We hope this call to action will drive a more joined up re-use and recycling supply chain and look forward to playing a part in future developments.”

MIKE TAYLOR, DIRECTOR, BRITISH HEART FOUNDATION

“The Circular Fibres Initiative and this report serve as a launchpad moment for those of us actively engaged in working to shift the global textiles economy towards a circular framework. Through our Fashion Positive initiative, the Cradle to Cradle Products Innovation Institute is proud to have been part of developing the report, which represents a monumental re-thinking of textile production and use throughout the entire value chain – establishing a truly circular platform for the industry and our economy. We encourage other organisations, businesses and governments to use this report as their own platform for taking immediate action.”

LEWIS PERKINS, PRESIDENT, CRADLE TO CRADLE PRODUCTS INNOVATION INSTITUTE



“The potential for circularity in clothing and apparel, where raw materials are kept in continual circulation, is completely achievable yet the barriers preventing it are challenging. We are extremely excited to see the dedicated team at the Ellen MacArthur Foundation applying its systemic approach to aggregating key players in the industry to work together and overcome these challenges. This report will no doubt play a crucial role in increasing exposure, intensifying efforts, and driving momentum towards a circular resource model for clothing and textiles to a time where the concept of textile waste has been relegated to the history books.”

CYNDI RHOADES, CEO, WORN AGAIN

“The circular economy provides an unprecedented opportunity to build restorative and fair approaches in the apparel industry. For the first time this report illuminates the challenges and resulting opportunities in creating endless flows of fibres. The report sets the stage for businesses to embrace and embed circular business models and technologies and more importantly forms a basis for systemic collaboration and convergence toward a new normal.”

JEFFREY HOGUE, CHIEF SUSTAINABILITY OFFICER, C&A

“It is easy to say that we need to change from a linear economic system to a circular one, it is much more difficult to do it. The report is addressing the textile story in a concrete and comprehensive way. Worth reading and even more worth supporting in practice the steps proposed.”

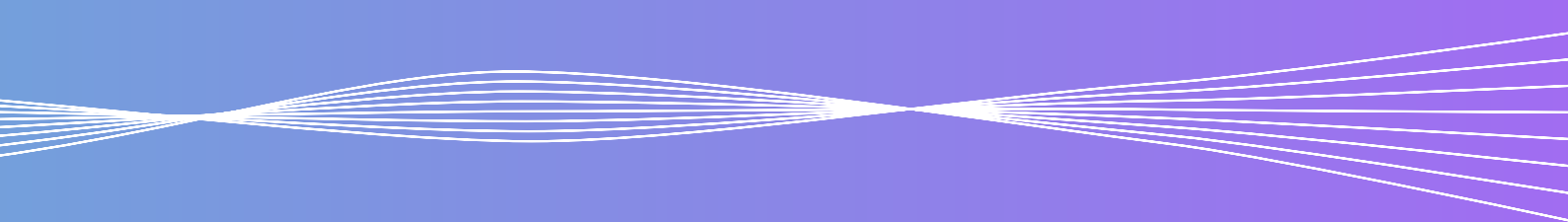
JANEZ POTOČNIK, CO-CHAIR, INTERNATIONAL RESOURCE PANEL

“Understanding the true impact of the fashion industry requires an in-depth review of the value-chain. Fibres are the first building block of this chain and a core element that needs to be understood to support the efforts on sustainable solutions for the industry. Based on the analysis provided through this report, it is possible to see new opportunities for rethinking the fashion systems that can be adapted both by designers and fashion businesses around the world.”

BURAK ÇAKMAK, DEAN SCHOOL OF FASHION, PARSONS SCHOOL OF DESIGN

“Painting a new vision of a future fashion system is a challenging task. This report accurately portrays the complexity of issues in the current failed system, and articulates in a holistic way to all stakeholders what needs to be done. Today’s garments cannot be reproduced into garments, and globally we lack collective focus on innovations that enable massive investments in global recycling systems. We at Mistra Future Fashion, a research program on sustainable fashion since 2011, see that this important report can play a key role globally in highlighting the challenges, especially within recycling, and mobilising multiple stakeholders towards a joint systemic goal.”

SIGRID BARNEKOW, PROGRAM DIRECTOR, MISTRA FUTURE FASHION



“Circular is the new black! We need a fashion industry based on three principles: clean, fair and good.”

ANTOINETTE GUHL, DEPUTY MAYOR OF PARIS, IN CHARGE OF CIRCULAR ECONOMY

“This is an incredibly thorough investigation of the problem and the opportunities that a circular economy for textiles presents to business and to society. We are honored to be included in this research, and are excited about the potential to collaborate to see regenerative textile technologies commercialised at scale.”

STACY FLYNN, CEO, EVRNU

“It is obvious that the current fashion system is failing both the environment and us. This report sets out a compelling vision of an industry that is not only creative and innovative, but also circular. To achieve such a necessary system change that will benefit society as a whole will require strong political will. Whilst this may not be straightforward, the way is now clear.”

IDA AUKEN, MEMBER OF PARLIAMENT, DENMARK

“At Fashion for Good, our ambition is to reimagine the way fashion is designed, made, worn and reused. But this type of systemic change can not happen in a bubble. An open innovation culture is crucial, and this report makes a strong case that pre-competitive collaboration between brands and producers is a key step in the transition to a circular textiles system.”

KATRIN LEY, MANAGING DIRECTOR, FASHION FOR GOOD

“The textile, apparel, and footwear industries have long been a strong force of industrialisation across the globe. At VF, we believe this unique position will be even stronger if the overall industry continues to transition to a new textiles economy based on a circular system that regenerates materials by offering opportunities for innovative design and increased consumer engagement while capturing economic value. This report illuminates the exciting opportunities for our sector, helping companies to understand circularity in practice.”

ANNA MARIA RUGARLI, SENIOR DIRECTOR, SUSTAINABILITY AND CORPORATE SOCIAL RESPONSIBILITY, VF EMEA

ACKNOWLEDGEMENTS

PHILANTHROPIC FUNDER

C&A Foundation

CORE PARTNERS



KNOWLEDGE PARTNER

McKinsey&Company

AFFILIATE PARTNERS



CORE PROJECT TEAM

Andrew Morlet, Chief Executive

Rob Opsomer, Systemic Initiatives Lead

Dr Sven Herrmann, Project Lead and Lead Author, Circular Fibres Initiative

Laura Balmund, Project Manager

Camille Gillet, Research Analyst

Lukas Fuchs, Research Analyst

We are very grateful for the support we have received in producing this report. Special thanks go to our Advisory Board and Expert Panel for their support, our Participating Organisations for their active involvement, and also to the many leading academic, industry, NGO, and government agency experts who provided invaluable perspectives.

FURTHER CONTRIBUTORS

ELLEN MACARTHUR FOUNDATION

Ian Banks, Editor

Jocelyn Blériot, Executive Officer, Head of Editorial and Public Affairs

Sarah Churchill-Slough, Design & Branding Manager

Clementine d'Oiron, Systemic Initiatives Network Manager

Lena Gravis, Editor

Julia Koskella, Researcher

Mimi Quaife, Sub-Editor

Aurélien Susnjara, Research Analyst

Rory Waldegrave, Design Apprentice

MCKINSEY & COMPANY

Clarisse Magnin, Senior Partner

Helga Vanthournout, Senior Expert

Saskia Hedrich, Senior Expert

Pinja Puustjärvi, Consultant

Alexia Semov, Consultant

Hammu Varjonen, Intern

C&A FOUNDATION

Leslie Johnston, Executive Director

Megan McGill, Programme Manager - Circular Transformation

Douwe Jan Joustra, Head Circular Transformation

H&M GROUP

Cecilia Strömblad Brännsten, Circular Economy Lead, acting Environmental Sustainability Manager

Emelie Olbrink, Sustainability Business Expert - Circular Economy and Innovation

Mattias Bodin, Sustainability Business Expert - Materials and Innovation

Anna Biverstål, Sustainability Business Expert - Chemicals

Laura Coppen, Creative Business Development - H&M Group Laboratory

Henrik Lampa, Development Sustainability Manager

LENZING AG

Sonja Zak, Head of Product Management BM Textiles

Krishna Manda, Senior Manager Sustainability Integration

Caroline Ledl, Product Manager

Christian Weilach, Project Manager Pulp and Biorefinery Technology

NIKE INC.

Virginia Borchardt, Sustainable Innovation Partnerships Manager

Adam Brundage, Senior Manager Data and Analytics, Sustainable Business and Innovation

Jim Goddard, GM Science and Technology, Sustainable Business and Innovation

Susi Proudman, Vice President of Materials (Apparel, Footwear and Equipment)

Shannon Shoul, Director of Sustainability Excellence

CONKER HOUSE

Joanna de Vries, Editor

Emma Parkin, Editor

EXPERT PANEL

Sandy Black, Professor of Fashion and Textile Design and Technology, Centre for Sustainable Fashion - University of the Arts London.

Dr Anna Brismar, Founder and Owner, Green Strategy

Burak Cakmak, Dean - School of Fashion, Parsons School of Design

Kristy Caylor, Co-founder, For Days

Julie Gilhart, Fashion Consultant

Lizzie Harrison, Founder and Creative Director, Antiform Online

Edwin Keh, Chief Executive Officer, Hong Kong Research Institute of Textiles and Apparel

Isaac Nichelson, Founder, S3 Source/Chief Executive Officer, Circular Systems SPC

Elisa Tonda, Head, Consumption and Production Unit, UN Environment

PARTICIPATING ORGANISATIONS

ADIDAS AG

Philipp Meister, Director Strategy Social and Environmental Affairs

Christoph Frechen, Senior Director of Marketing

Alexis Haass, Director of Sustainability, Brand Strategy & Business Development

Connor Hill, Sustainability & Circularity Manager

ADITYA BIRLA GROUP

Manohar Samuel, President-Marketing, Birla Cellulose

Naresh Tyagi, Chief Sustainability Officer, Aditya Birla Fashion and Retail

APEX SPINNING AND KNITTING MILLS LIMITED

Eifaz Ahmed, Director

ASOS PLC

Tara Luckman, Senior Sustainability Manager

BANK & VOGUE / BEYOND RETRO

Neda Hashemi, Global PR, Marketing and Events Manager

Steve Bethell, President and Partner, Bank and Vogue

Sue McLennan, Vice President Sustainability and Business Development, Bank and Vogue

BESTSELLER A/S

Dorte Rye Olsen, Sustainability Manager

BRITISH HEART FOUNDATION

David Roman, Waste & Recycling Manager

BURBERRY GROUP PLC

Jocelyn Wilkinson, Responsibility Programme Director

C&A

Jeffrey Hogue, Chief Sustainability Officer

Charline Ducas, Unit Leader of Global Circular Economy

CATALONIA

Maite Ardevol, Circular Economy Coordinator, ACCIÓ

COMMON OBJECTIVE

Clare Lissaman, Director, Product and Impact

DANISH EPA

Emilie Mille Müller, Cirkulær Økonomi & Affald

Anne-Mette Lysemose Bendsen, Miljøteknologi

EASTMAN EXPORTS GLOBAL CLOTHING PVT LTD

Ugamoorthi Ramakrishnan, General Manager Laboratory/Sustainability/R&D

EILEEN FISHER INC.

Candice Reffe, Chief Impact and Innovation Officer

FARM RIO

Taciana Abreu, Head of Marketing and Sustainability

FILIPPA K AB

Elin Larsson, Sustainability Director

FUNG GROUP

Pamela Mar, Director of Sustainability

GAP INC.

Melissa Fifield, Senior Director, Sustainable Innovation

GEETANJALI WOOLLENS PVT LTD

Deepak Goel, Managing Director

HOUDINI SPORTSWEAR AB

Eva Karlsson, Chief Executive Officer

INDITEX

Alfred Vernis Domenech, Sustainability Academic Director

I:COLLECT

Paul Doertenbach, Head of Sales & Account Management

Lydia Schmidt, Key Account Manager

KERING

Cecilia Takayama, Director, Material Innovation Lab

LEVI STRAUSS & CO

Liza Schillo, Manager, Product Sustainability

Kelsey Pecherer, Manager, Sustainable Business and Marketing

LOJAS RENNER

Vinicios Malfatti, Senior Manager of Sustainability and Executive Director of Institute

MARKS AND SPENCER

Mark Yates, Head of Innovation and Quality, Menswear

OVAM/CIRCULAR FLANDERS

Veerle Spaepen, Project Manager Circular Fashion (and Cities), and Co-creator, 'Close the Loop' Platform

OVS SPA

Simone Colombo, Head of Corporate Sustainability

PATAGONIA INC.

Nellie Cohen, Worn Wear Program Manager

CITY OF PHOENIX

Ginger Spencer, Public Works Director

TOMMY HILFIGER

Esther Verburg, Vice President Corporate Responsibility Tommy Hilfiger Global/PVH Europe

REBLEND

Anita de Wit, Co-founder

REDE ASTA

Alice Freitas, Diretora Executiva

SOEX GROUP

Vittoria Troppenz, Business Development Manager

STELLA MCCARTNEY

Debra Guo, Sustainability Manager

Claire Bergkamp, Head of Sustainability and Ethical Trade

TRANS-AMERICAS TEXTILE RECYCLING INC.

Eric Stubin, Chief Executive Officer

VF CORPORATION

Anna Maria Rugarli, Sustainability & Responsibility Senior Director

Julian Lings, Sustainability & Responsibility Manager, The North Face EMEA

VIGGA

Peter Svensson, Co-founder

WRAP

Keith James, Textiles Delivery Manager

Cecile Martin, Technical Specialist

WORN AGAIN

Cyndi Rhoades, Chief Executive Officer

EXPERT CONTRIBUTORS

Antonio Achille, Senior Partner, McKinsey & Company

Lucie Ackermann, Project Manager, Valvan Baling Systems

Marisa Adler, Senior Consultant, Resource Recycling Systems

Dr Matti Aistrich, Senior Lead, The Finnish Innovation Fund Sitra

Dr Weber Amaral, Professor, University Sao Paulo

Anne-Sophie Andersson, Executive Director, ChemSec

Charles Arden-Clarke, Head, 10YFP Secretariat, UN Environment

Enrica Arena, Co-founder and Chief Marketing Officer, Orange Fiber

Sandra Averous, Programme Officer, Consumption and Production Unit, UN Environment

Erik Bang, Innovation Lead, H&M Foundation

Ayesha Barenblat, Founder, Remake

Sigrid Barnekow, Program Director, Mistra Future Fashion/RISE

Nicole Bassett, Co-founder, The Renewal Workshop

Achim Berg, Senior Partner, McKinsey & Company

Matteo Bertelè, Chief Financial Officer, Gr3n Recycling

Dr Nancy Bocken, Professor, Lund University; Associate Professor, Delft University of Technology

Martin Bösch, Chief Executive Officer, Texaid

Dr Julien Boucher, Associate Executive Director, EA Shaping Environmental Action

Clare Brass, Director, Department 22

Julie Brown, Product Manager, Sustainable Apparel Coalition

James Carnahan, Global Sustainability Manager, Archroma

Nin Castle, Co-founder, Reverse Resources

Amanda Cattermole, Founder and Chief Executive Officer, Cattermole Consulting

Franco Antonio Cavadini, Chief Technical Officer, Synesis s.c.ar.l.

Dr Sarah Cornell, Researcher and Project Coordinator, Stockholm Resilience Centre at Stockholm University

Paul Cowell, Global Head of Brand Marketing, Archroma

Gwen Cunningham, Lead, Circle Textiles Programme, Circle Economy

Dr Kirsti Cura, Development Manager, Lahti University of Applied Sciences

Dr Hanna de la Motte, Recycling Lead, RISE/Mistra Future Fashion

Sander Defruyt, Project Manager, New Plastics Economy, Ellen MacArthur Foundation

Richard Delahay, Managing Director, Sustainability Consult

Dr Michiel De Smet, Project Manager, New Plastics Economy, Ellen MacArthur Foundation

Maura Dilley, Fashion Positive Community Manager, Cradle to Cradle Products Innovation Institute

Mart Drake-Knight, Co-founder, Rapanui Clothing Ltd.

Dunja Drmač, Sustainability Officer, Euratex

Benjamin Durand-Servoingt, Associate Partner, McKinsey & Company

Scott Echols, Programme Director, Zero Discharge of Hazardous Chemicals

Jonas Eder-Hansen, Chief Content Officer, Danish Fashion Institute/Global Fashion Agenda

Dr Mika Horttanainen, Professor, Lappeenranta University of Technology

Maria Elander, Project Lead SIPTex, IVL Swedish Environmental Research Institute

Nik Engineer, Global Partnerships Lead, Ellen MacArthur Foundation

Stacy Flynn, Chief Executive Officer, Evrnu

Ashley Gill, Senior Manager of Industry Integrity, Textile Exchange

Dr Kate Goldsworthy, Design Lead, Mistra Future Fashion/University of the Arts London

Annie Gullingsrud, Director Textiles and Apparel Sector, Cradle to Cradle Products Innovation Institute

Sara Li-Chou Han, Research Associate, Manchester Metropolitan University

David Hasanat, Chairman, Viyellatex Group

Jukka Heikkilä, Managing Director, Lounais-Suomen Jätehuolto Oy, Telaketju Project

Pirjo Heikkilä, Senior Scientist, VTT, Telaketju Project

Lauren Heine, Executive Director, Northwest Green Chemistry

Tonnis Hooghoudt, Chief Executive Officer, Ioniqa Technologies

Joe Iles, Editor in Chief, Circulate, Ellen MacArthur Foundation

Sini Ilmonen, Circular Economy Specialist, Lounais-Suomen Jätehuolto Oy, Telaketju Project

Dr Reimer Ivang, Chief Executive Officer and Co-founder, Better World Fashion

Thorston Jelinek, Managing Director, Polyterra Innovation

Greg Kelly, Senior Partner, McKinsey & Company

Gabriella Keyles, Manager of Stakeholder Engagement, Future 500

Jason Kibbey, Chief Executive Officer, Sustainable Apparel Coalition

Aimee Kim, Senior Partner, McKinsey & Company

Traci Kinden, Project Manager, Circle Textiles Programme, Circle Economy

Theresa Kjell, Senior Business and Policy Advisor, ChemSec

Kellen Klein, Senior Manager of Stakeholder Engagement, Future 500

Jörn Küpper, Senior Partner, McKinsey & Company

Deepti Lahane, Chief Manager-Market Intelligence, Fibre2fashion

Annabelle Lampe, Product Developer, Wolkat

Amy Lee, Global Trends and Insights Specialist, Avery Dennison RBIS

Delphine Lévi Alvarès, European Coordinator of the #BreakFreeFromPlastic movement and Coordinator of the 'Rethink Plastic' Alliance, Zero Waste Europe

Jerker Ligthart, Senior Chemicals Advisor, ChemSec

Dr Mats Linder, Project Manager, New Plastics Economy, Ellen MacArthur Foundation

Karla Magruder, Founder and President, Fabrikology International

Dr Alenka Majcen Le Maréchal, Professor, University of Maribor

Dieter Messner, General Manager, Europe and Americas, Esprit Europe GmbH

Frank Michel, Executive Director, Zero Discharge of Hazardous Chemicals

Dr Karen Miller, Visiting Industrial Fellow and Researcher, University of Cambridge

Jo Mourant, Former Senior Consultant, MADE-BY

Clare Ollerenshaw, Circular Economy Manager, London Waste and Recycling Board

Dr Aldo Ometto, Professor, University Sao Paulo

Lewis Perkins, President, Cradle to Cradle Products Innovation Institute

Dr Pamela Ravasio, Head of CSR & Sustainability, European Outdoor Group

Nathalie Remy, Partner, McKinsey & Company

Trewin Restorick, Founder and Chief Executive Officer, HUBBUB

Ronnie Robinson, Chief Sourcing Officer, J Crew Group

Ariadna Rodrigo, Product Policy Campaigner, Zero Waste Europe

Ann Runnel, Founder, Reverse Resources

Dominik Salzer, Team Leader Corporate Brand Development, HUGO BOSS AG

Adriana Santanocito, Co-founder & Chief Executive Officer, Orange Fiber

Mauro Scalia, Sustainable Businesses Manager, Euratex

Lucy Shea, Chief Executive Officer, Futerra

Hélène Smits, Business Development Manager, Recover

Daniel Solomita, Founder, Loop Industries

François Souchet, Project Manager, Ellen MacArthur Foundation

Eveline Speelman, Senior Project Lead, McKinsey & Company

Dr Katy Stevens, Sustainability Project Manager, European Outdoor Group



Alexandra Stewart, Scientific Officer, The Swedish Chemicals Agency

Colin Strong, Global Head of Behavioural Science, Ipsos

Steven Swartz, Expert Partner, McKinsey & Company

Susanne Sweet, Stockholm School of Economics and Research Manager, Mistra Future Fashion

Evonne Tan, Information Architect & Creative Designer, Textile Exchange

Sofia Tärneberg, Content Manager, Danish Fashion Institute

David Tyler, Reader, Manchester Metropolitan University

Dr Natascha van der Velden, Independent Researcher

Kimberly van der Wal, Business Developer, Wolkat

Bert van Son, Chief Executive Officer and Founder, MUD jeans

Martijn van Strien, Founder, The Post-Couture Collective

Yannick Vicaire, Detox Campaign Strategist, Greenpeace

Rachel Wallace, Programme Project Manager, Zero Discharge of Hazardous Chemicals

Lutz Walter, R&D and Innovation Manager, Euratex

Dr Michael Warhurst, Executive Director, CHEM Trust

David Watson, Senior Consultant, PlanMiljø ApS

Emma Westerholm, Scientific Officer, The Swedish Chemicals Agency

Stiv Wilson, Campaigns Director, Story of Stuff

Tamara Zwart, Special Projects Europe, Cradle to Cradle Products Innovation Institute



DISCLAIMER

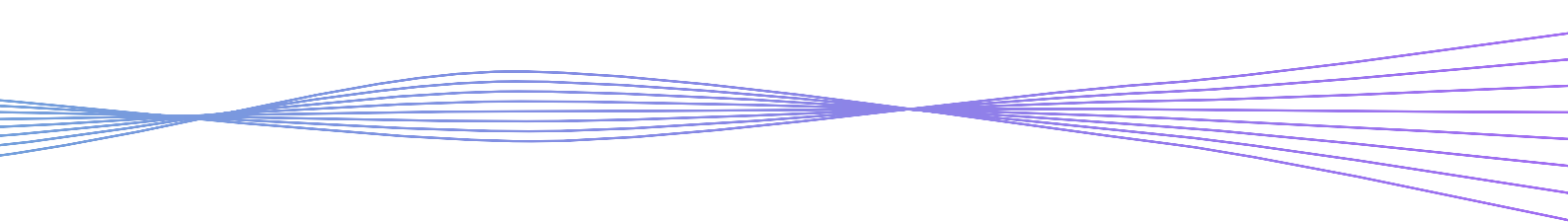
This report has been produced by a team from the Ellen MacArthur Foundation, which takes full responsibility for the report's contents and conclusions. McKinsey & Company provided analytical support. While the Participating Organisations, Affiliate Partners, members of the Advisory Board and Expert Panel, and those experts who were consulted and acknowledged on the previous pages have provided significant input to the development of this report, their participation does not necessarily imply endorsement of the report's contents or conclusions.

To quote this report, please use the following reference:

Ellen MacArthur Foundation, *A new textiles economy: Redesigning fashion's future*, (2017, <http://www.ellenmacarthurfoundation.org/publications>).

Partners of the Ellen MacArthur Foundation





CONTENTS

EXECUTIVE SUMMARY	3
In support of the report	4
Acknowledgements	8
SUMMARY OF FINDINGS	18
PART I: THE CASE FOR RETHINKING THE GLOBAL TEXTILES SYSTEM, STARTING WITH CLOTHING	35
PART II: A NEW TEXTILES ECONOMY IS AN ATTRACTIVE VISION OF A SYSTEM THAT WORKS	43
1. Phase out substances of concern and microfibre release	52
2. Transform the way clothes are designed, sold, and used to break free from their increasingly disposable nature	72
3. Radically improve recycling by transforming clothing design, collection, and reprocessing	90
4. Make effective use of resources and move to renewable inputs	108
Appendix A. Overview of common textile materials	119
Appendix B. Methodology overview	122
Endnotes	132

SUMMARY OF FINDINGS

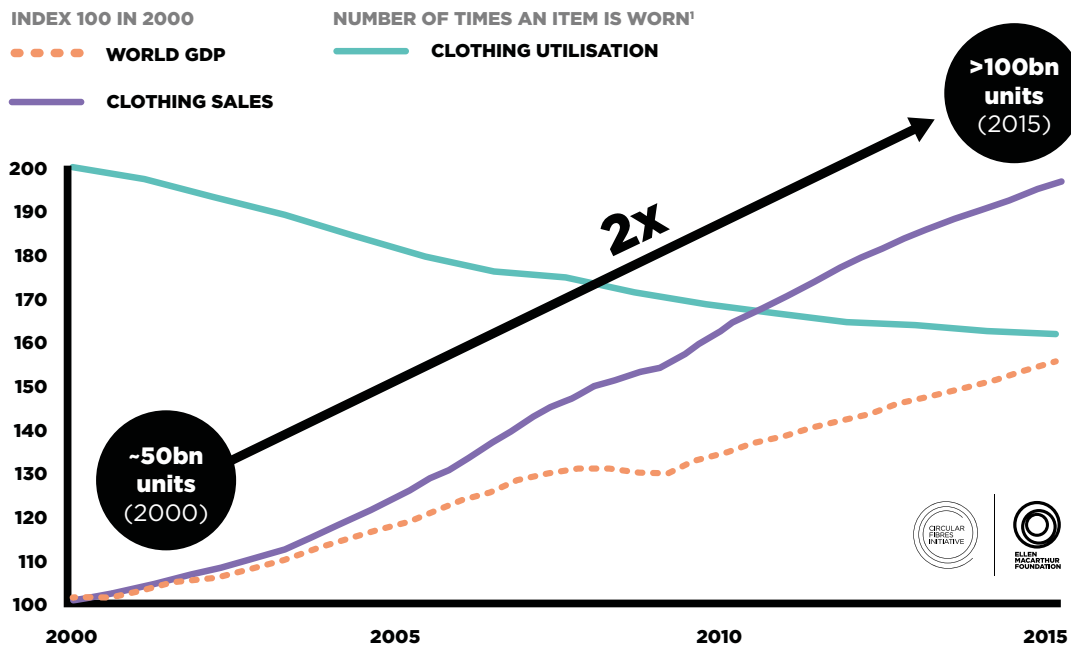
The case for rethinking the global textiles system, starting with clothing

Textiles and clothing are a fundamental part of everyday life and an important sector in the global economy. It is hard to imagine a world without textiles. Clothes are worn by almost everyone, nearly all the time, and for many are an important expression of individuality. Globally, the USD 1.3 trillion clothing industry employs more than 300 million people along the value chain; the production of cotton alone accounts for almost 7% of all employment in some low-income countries.¹ Clothing² - the focus of this report - represents more than 60%

of the total textiles used and is expected to remain the largest application.³

In the last 15 years, clothing production has approximately doubled (see Figure 1), driven by a growing middle-class population across the globe and increased per capita sales in mature economies. The latter rise is mainly due to the 'fast fashion' phenomenon, with quicker turnaround of new styles, increased number of collections offered per year, and - often - lower prices.

FIGURE 1: GROWTH OF CLOTHING SALES AND DECLINE IN CLOTHING UTILISATION SINCE 2000



1 Average number of times a garment is worn before it ceases to be used

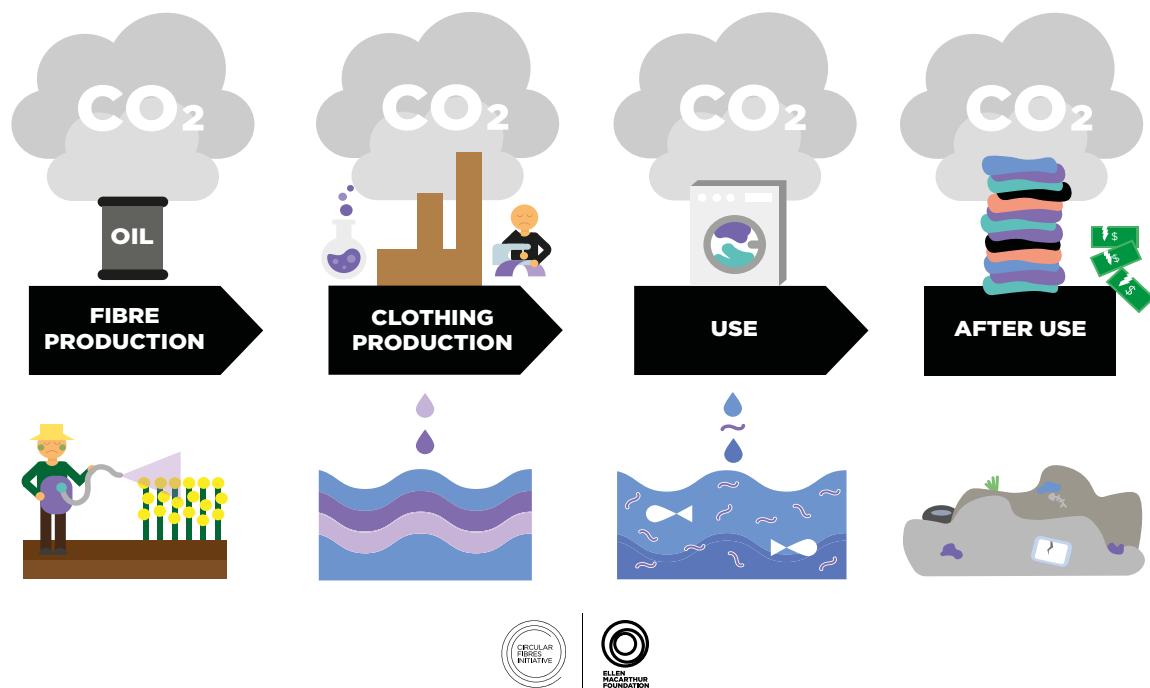
Source: Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005-2015); World Bank, *World development indicators - GD* (2017)

The current clothing system is extremely wasteful and polluting

The current system for producing, distributing, and using clothing operates in an almost completely linear way. Large amounts of non-renewable resources are extracted to produce clothes that are often used for only a short period,⁴ after which the materials are largely lost to landfill or incineration. It is estimated that more than half of fast fashion produced is disposed of in under a year.⁵ This linear system leaves economic opportunities untapped, puts

pressure on resources, pollutes and degrades the natural environment and its ecosystems, and creates significant negative societal impacts at local, regional, and global scales (see Figure 2). The economic value of these negative externalities is difficult to quantify, although the recent *Pulse of the fashion industry* report estimated that the overall benefit to the world economy could be about EUR 160 billion (USD 192 billion) in 2030 if the fashion industry were to address the environmental and societal fallout of the current status quo.⁶

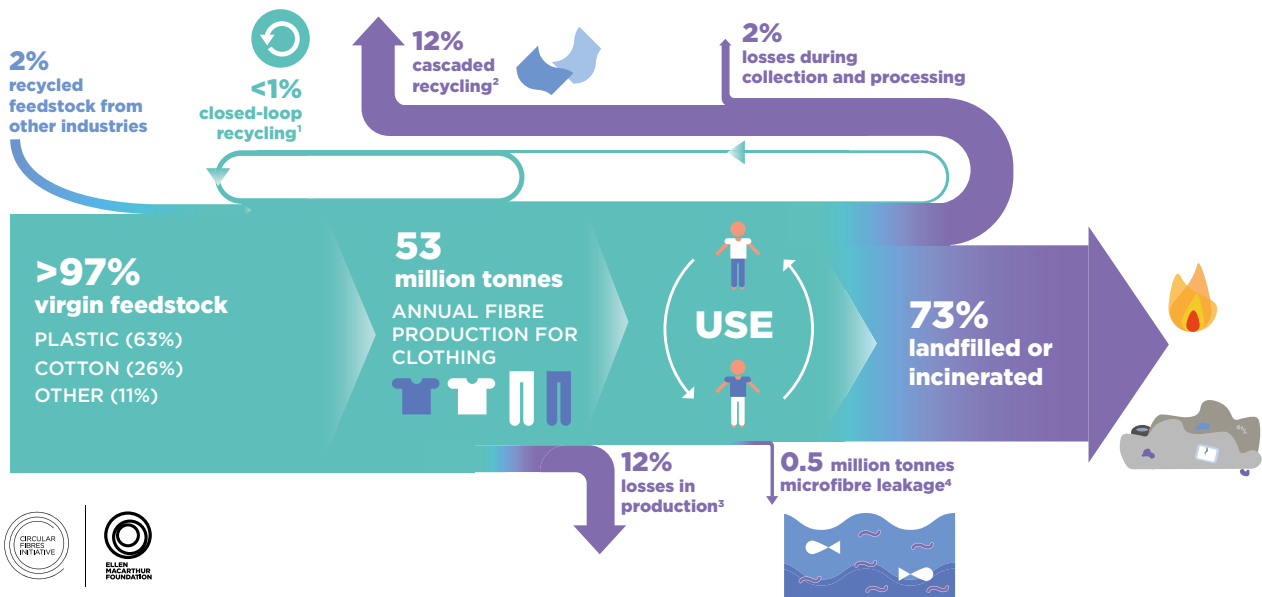
FIGURE 2: TODAY'S CLOTHING SYSTEM PUTS PRESSURE ON RESOURCES, POLLUTES THE ENVIRONMENT, AND CREATES NEGATIVE SOCIETAL IMPACTS



Clothing is massively underutilised. Worldwide, clothing utilisation – the average number of times a garment is worn before it ceases to be used – has decreased by 36% compared to 15 years ago.⁷ While many low-income countries have a relatively high rate of clothing utilisation, elsewhere rates are much lower. In the US, for example, clothes are only worn for around a quarter of the global average. The same pattern is emerging in China, where clothing utilisation has decreased by 70% over the last 15 years.⁸

Globally, customers miss out on USD 460 billion of value each year by throwing away clothes that they could continue to wear,⁹ and some garments are estimated to be discarded after just seven to ten wears.¹⁰ Clothing users are acknowledging this as a problem, with, for example, 60% of German and Chinese citizens admitting to owning more clothes than they need.¹¹

FIGURE 3: GLOBAL MATERIAL FLOWS FOR CLOTHING IN 2015



- 1 Recycling of clothing into the same or similar quality applications
- 2 Recycling of clothing into other, lower-value applications such as insulation material, wiping cloths, or mattress stuffing
- 3 Includes factory offcuts and overstock liquidation
- 4 Plastic microfibres shed through the washing of all textiles released into the ocean

Source: Circular Fibres Initiative analysis – for details see Appendix B

Less than 1% of material used to produce clothing is recycled into new clothing,¹³ representing a loss of more than USD 100 billion worth of materials each year.¹⁴ As well as significant value losses, high costs are associated with disposal: for example, the estimated cost to the UK economy of landfilling clothing and household textiles each year is approximately GBP 82 million (USD 108 million).¹⁵ Across the industry, only 13% of the total material input is in some way recycled after clothing use (see Figure 3). Most of this recycling consists of cascading to other industries and use in lower-value applications, for example, insulation material, wiping cloths, and mattress stuffing – all of which are currently difficult to recapture and therefore likely constitute the final use.¹⁶

Even though some countries have high collection rates for reuse and recycling (such as Germany, which collects 75% of textiles),¹⁷ much of the collected clothing in such countries is exported to countries with no collection infrastructure of their own. These valuable efforts increase clothing utilisation, though ultimately most of these clothes end up in landfills or are cascaded to lower-value applications.¹⁸

Today’s linear system uses large amounts of resources and has negative impacts on the environment and people. The textiles industry relies mostly on non-renewable resources – 98 million tonnes in total per year – including oil to produce synthetic fibres, fertilisers to grow cotton, and chemicals to produce, dye, and finish fibres and textiles.¹⁹ Textiles production (including cotton farming) also uses around 93 billion cubic metres of water annually,²⁰ contributing to problems in some water-scarce regions. With its low rates of utilisation (leading to high levels of throughput) and low levels of recycling, the current wasteful, linear system is the root cause of this massive and ever-expanding pressure on resources.

The industry’s immense footprint extends beyond the use of raw materials. In 2015, greenhouse gas (GHG) emissions from textiles production totalled 1.2 billion tonnes of CO₂ equivalent,²¹ more than those of all international flights and maritime shipping combined.²² The industry also has direct local impacts. The use of substances of concern in textile production has negative effects on farmers, factory workers, and the surrounding environment. While there is little data on the volume of substances of concern used across the industry, it is recognised that textile production discharges

high volumes of water containing hazardous chemicals into the environment. As an example, 20% of industrial water pollution globally is attributable to the dyeing and treatment of textiles.²³

In recent years, the textiles industry has been identified as a major contributor to the issue of plastic entering the ocean, which is a growing concern because of the associated negative environmental and health implications. It has been estimated that around half a million tonnes of plastic microfibres shed during the washing of plastic-based textiles such as polyester, nylon, or acrylic end up in the ocean annually.²⁴

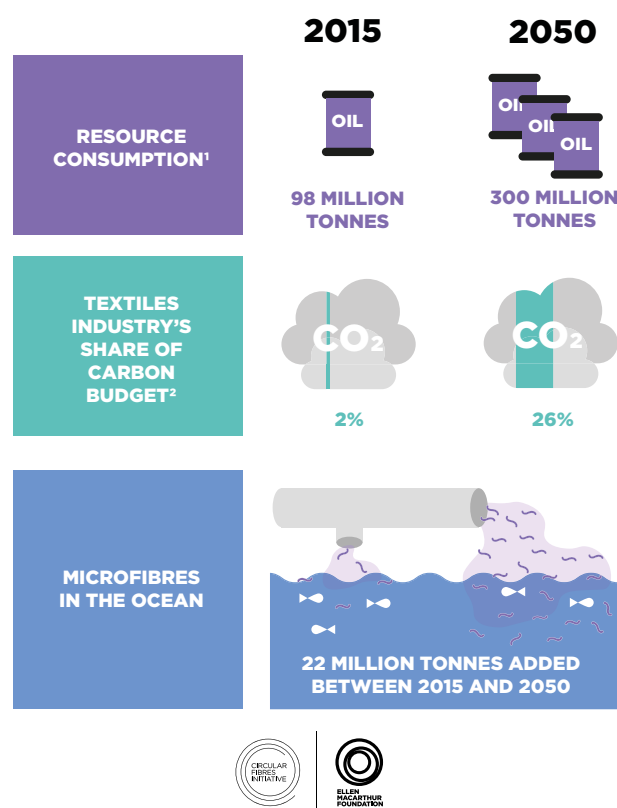
Today's textiles system also has multiple negative societal impacts. Many workers face dangerous working environments due to unsafe processes and the hazardous substances used in production. High cost and time pressures are often imposed on all parts of the supply chain,²⁵ which can lead to workers suffering poor working conditions with long hours and low pay,²⁶ with evidence, in some instances, of modern slavery and child labour.²⁷ The potential for negative societal impacts does not stop at the factory door. Local communities, while benefitting from employment in the industry, may suffer from its poor environmental practices. For example, discharging untreated production wastewater pollutes local rivers used for fishing, drinking, or bathing.

The trajectory of the industry points to the potential for catastrophic outcomes

Demand for clothing is continuing to grow quickly, driven particularly by emerging markets, such as Asia and Africa. Should growth continue as expected, total clothing sales would reach 160 million tonnes in 2050 – more than three times today's amount.²⁸ This would result in a substantial increase in the negative impacts of the industry (including those shown in Figure 4).

On current trend, the negative impacts of the industry will be potentially catastrophic. If the industry continues on its current path, by 2050, it could use more than 26% of the carbon budget associated with a 2°C pathway.²⁹ Moving away from the current linear and wasteful textiles system is therefore crucial to keeping within reach the 2°C average global warming limit.

FIGURE 4: THE NEGATIVE IMPACTS OF THE TEXTILES INDUSTRY ARE SET TO DRASTICALLY INCREASE BY 2050

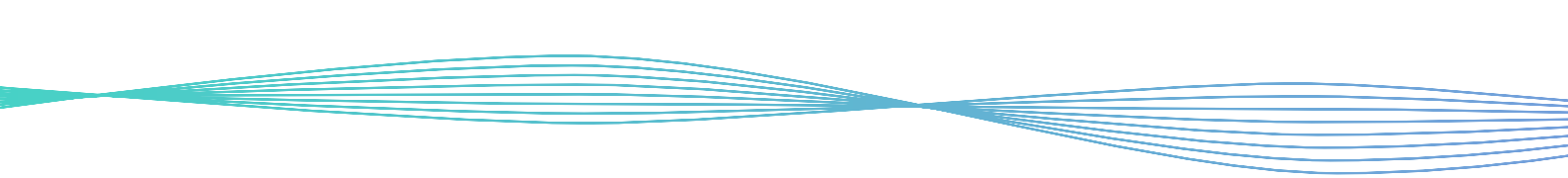


- 1 Consumption of non-renewable resources of the textiles industry, including oil to produce synthetic fibres, fertilisers to grow cotton, and chemicals to produce, dye, and finish fibres and textiles
- 2 Carbon budget based on 2 degrees scenario

Source: Circular Fibres Initiative analysis – for details see Part I

Under a business-as-usual scenario, the growth in material volume of textiles would see an increasing amount of non-renewable inputs, up to 300 million tonnes per year by 2050. On current trend, the amount of plastic microfibres entering the ocean between 2015 and 2050 could accumulate to an excess of 22 million tonnes – about two thirds of the plastic-based fibres currently used to produce garments annually.

Profitability of the industry is at risk. The *Pulse of the fashion industry* report projects that, by 2030, fashion brands would see a decline in earnings before interest and tax (EBIT) margins of more than three percentage points, if they were to continue business as usual. This would translate into a profit reduction of approximately EUR 45 billion (USD 52 billion) for the industry.³⁰



Additionally, the negative impacts of the industry are becoming more transparent and understood by digitally-enabled customers, leading to reputational risks for brands and to regulatory trends that could affect the profits of businesses that fail to respond. High-profile incidents, like the Rana Plaza disaster in 2013 in which over 1,000 workers were killed,³¹ have drawn international attention to the societal

impacts associated with the clothing value chain and NGOs are generating awareness of the industry's negative environmental impact.³² Recently, the industry has also been challenged to find systemic solutions to tackle 'overconsumption', moving beyond downstream, short-term approaches to reduce the industry's impact.³³

A new textiles economy – based on circular economy principles – would lead to better outcomes

In recent years, the industry and its customers have become increasingly aware of the negative environmental and societal impacts of the current system. Brands and retailers have started to address specific environmental or societal challenges within their supply chains, both individually and through industry-wide organisations and initiatives. However, most of these efforts are focused on reducing the impact of the current linear system – for example, by using more efficient production techniques or reducing the impact of materials – rather than taking an upstream, systemic approach to tackling the root cause of the system's wasteful nature directly, in particular, low clothing utilisation and low rates of recycling after use.

This report proposes a vision for a new textiles economy aligned with the principles of a circular economy:³⁴ one that is restorative and regenerative by design and provides benefits for business, society, and the environment.³⁵ This vision is distinct from, and complements, ongoing efforts to make the textiles system more sustainable by minimising its negative impacts.

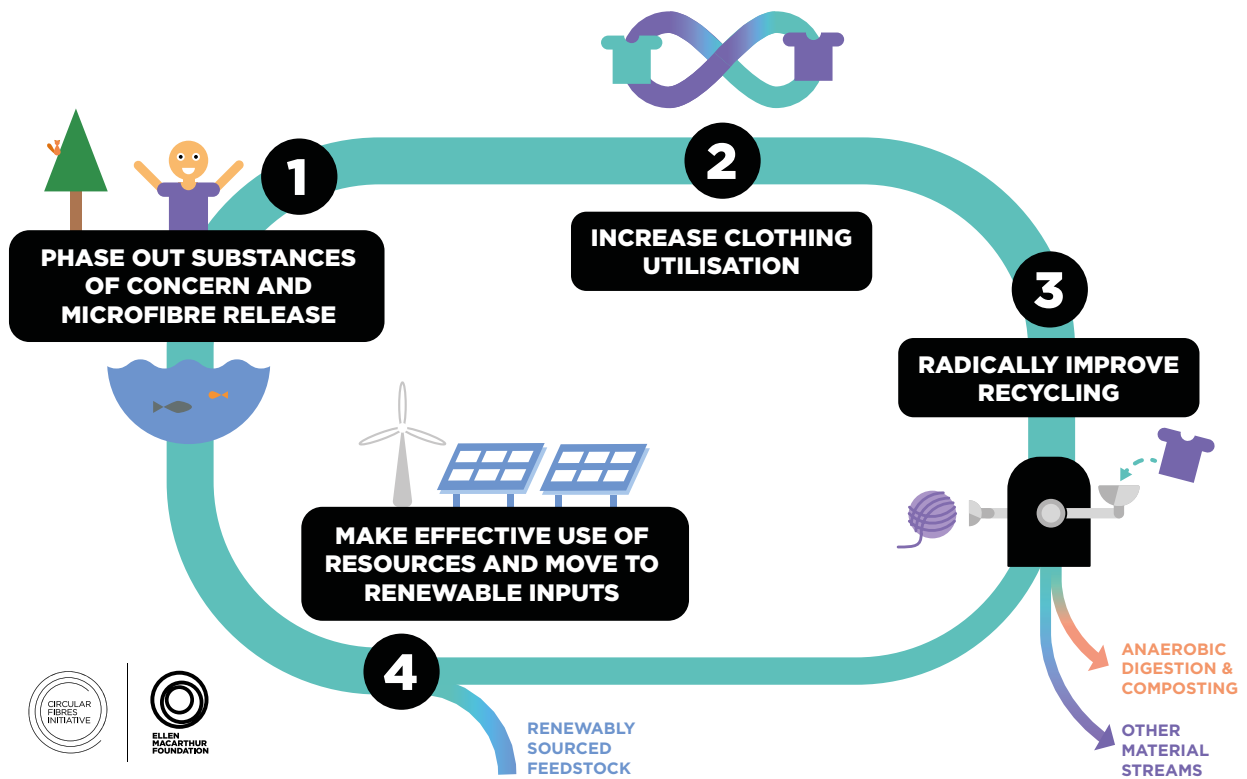
In such a new textiles economy, clothes, fabric, and fibres are kept at their highest value during use, and re-enter the economy after use, never ending up as waste. This would provide a growing world population with access to high-

quality, affordable, and individualised clothing, while regenerating natural capital, designing out pollution, and using renewable resources and energy. Such a system would be distributive by design, meaning value is circulated among enterprises of all sizes in the industry so that all parts of the value chain can pay workers well and provide them with good working conditions.

A new textiles economy relies on four ambitions (see Figure 5). It would lead to better economic, environmental, and societal outcomes, capturing opportunities missed by the current, linear, textiles system. When implementing these ambitions, each will come with a variety of different solutions for different applications, and their interactions need to be taken into account.

Realising these ambitions will not happen overnight. While there are some immediate profit opportunities for individual businesses, collaborative efforts across the value chain, involving private and public sector actors, are required to truly transform the way clothes are designed, produced, sold, used, collected, and reprocessed. However, this should not discourage or delay action. The time to act is now, and the ambitions below offer an attractive target state for the industry to align on and innovate towards.

FIGURE 5: AMBITIONS FOR A NEW TEXTILES ECONOMY



1

Phase out substances of concern and microfibres release

First and foremost, a new textiles economy needs to ensure that the material input is safe and healthy to allow cycling and to avoid negative impacts during the production, use, and after-use phases. This means that substances that are of concern to health or the environment are designed out and no pollutants such as plastic microfibres are inadvertently released into the environment and ocean.

The following two areas of action could kick-start this transition:

- **Align industry efforts and coordinate innovation to create safe material cycles.** Elimination of substances of concern is needed to enable large-scale recycling, as well as to avoid various negative impacts

at all stages of the value chain. Improved transparency along the value chain, a robust evidence base, and common standards would facilitate the phase-out of substances of concern. While some hazardous substances could be phased out quickly, innovation will be required to create new process inputs (e.g. dyes and additives), production processes, as well as textile materials, to fully phase out negative impacts related to substances of concern.

- **Drastically reduce plastic microfibres release.** New materials and production processes that radically reduce the number of plastic microfibres shed by clothing, alongside technologies that work effectively at scale to capture those that do still shed, are essential for this to be feasible. A better understanding of the causes of microfibres shedding will continue to inform solutions and identify gaps.

2

Transform the way clothes are designed, sold, and used to break free from their increasingly disposable nature

Increasing the average number of times clothes are worn is the most direct lever to capture value and design out waste and pollution in the textiles system. Designing and producing clothes of higher quality and providing access to them via new business models would help shift the perception of clothing from being a disposable item to being a durable product. As the acts of buying and wearing clothes fulfil a complex array of customer needs and desires, a variety of sales and service models is needed in a new textiles economy. Economic opportunities already exist in various market segments, and brands and retailers could exploit these through refocused marketing. The take-up of new opportunities would benefit from collaborative action to stimulate the development of innovative business models. Such action would also help unlock potential where the immediate economic case is not yet evident at scale.

Three areas of action would speed the transition towards this ambition:

- **Scale up short-term clothing rental.** When garments can be worn more often than a customer is able or willing to do, rental models could provide an appealing business opportunity. For customers desiring frequent outfit changes, subscription-based models can offer an attractive alternative to frequently buying new clothes. For garments where practical needs change over time, for example, children's clothes or those for one-off occasions, rental services would increase utilisation by keeping garments in frequent use rather than in people's closets. For all these models, refocused marketing – using the vast experience and capacity that brands and retailers have – and optimised logistics are key enablers for stimulating growth of new service offerings.
- **Make durability more attractive.** While short-term clothing rental can capture the value of durability by distributing clothing

use between many different people, for certain clothing types and customer segments, quality and durability can be of value even if there is only one or a few users. In these segments, many customers value high-quality, durable clothes, but a lack of information prevents the full value capture. For clothes that have already been used and become unwanted, but which are still durable enough to be used again, enhanced resale models offer an attractive opportunity. A focus on delivering quality purchases that last longer also encourages new technologies to be exploited that offer better fit and customisation for maximum customer satisfaction.

- **Increase clothing utilisation further through brand commitments and policy.** Driving high usage rates requires a commitment to design garments that last – an industry transition which could be advanced through common guidelines, aligned efforts, and increased transparency. Policymakers can also have an important role in further increasing clothing utilisation.

3

Radically improve recycling by transforming clothing design, collection, and reprocessing

There is a compelling case for radically improving recycling to allow the industry to capture the value of the materials in clothes that can no longer be used. Increasing recycling represents an opportunity for the industry to capture some of the value in more than USD 100 billion worth of materials lost from the system every year, as well as to reduce the negative impacts of their disposal.³⁶

A combination of demand and supply-side measures in the following four areas would be needed to realise this ambition:

- **Align clothing design and recycling processes.** Currently, clothing design and production typically do not consider what will happen when clothes cannot be used anymore. Converging towards a range of materials (including blends where those are

needed for functionality), and developing efficient recycling processes for these, is a crucial step in scaling up recycling, as is the development of new materials, where current ones do not provide the desired functionality and recyclability. Alignment is also needed to provide tracking and tracing technologies to identify materials in the recycling process.

- **Pursue technological innovation to improve the economics and quality of recycling.**

Existing recycling technologies for common materials need to drastically improve their economics and output quality to capture the full value of the materials in recovered clothing. A shared innovation agenda is needed to focus efforts and investments towards recycling technologies for common materials. Improved sorting technologies would also support increased quality of recycling by providing well-defined feedstock, in particular in the transition phase until common tracking and tracing technologies exist.

- **Stimulate demand for recycled materials.**

Increasing demand for recycled materials through clear commitments to using more recycled input could drastically accelerate the uptake of clothing recycling. Better matching supply and demand through increased transparency and communication channels, as well as policy, would further help stimulate demand.

- **Implement clothing collection at scale.**

Clothing collection needs to be scaled up dramatically alongside recycling technologies and, importantly, implemented in locations where it currently does not exist. Creating demand for recycled materials will increase markets for non-wearable items, dramatically improving the opportunity for collectors to capture value from these materials. Guidelines on comprehensive collection – based on current best practices and further research on optimal collection systems – would help scale up collection. These guidelines should include a set of global collection archetypes, allowing for regional variation but building on a set of common principles.

4

Make effective use of resources and move to renewable inputs

The need for raw material inputs in a new textiles economy would be drastically reduced due to higher clothing utilisation and increased recycling (Ambitions 2 and 3 above). However, virgin material input will likely always be required. Where such input is needed and no recycled materials are available, it should increasingly come from renewable resources. This means using renewable feedstock for plastic-based fibres and regenerative agriculture to produce any renewable resources.

In addition, transitioning to more effective and efficient production processes – that generate less waste (such as offcuts), need fewer inputs of resources, such as fossil fuels and chemicals, reduce water use in water-scarce regions, are energy efficient, and run on renewable energy – can further contribute to reducing the need for non-renewable resource input. Accounting for and reporting the costs of negative externalities would further support the shift to better resource use and production processes, and thereby generate system-wide benefits.

Achieving a new textiles economy demands a new level of alignment and collaboration

To move beyond incremental improvements and achieve a shift to a new textiles economy, a concerted, global, systemic, and collaborative approach is needed that matches the scale of the challenge and the opportunity.

Transforming the textiles industry into a circular economic model requires system-level change

Moving towards a circular economy goes far beyond traditional measures to reduce the negative impacts of the current linear system. It entails shifting to an entirely new system, and cannot be achieved merely through incremental improvements.

Systems thinking has gained increased attention in recent years as a required approach for overcoming complex, systemic issues. It is still a new science and only a few case studies and enabling tools are available to support companies and industries to transform. Even if such tools were available, changing a complex system is not something that can be planned and executed in a static, deterministic way. A design-thinking approach is required, bringing actors together from across the system to collaborate, prototype, learn, refine, and scale what works.

The key characteristics of a system-level change approach to move a value chain towards a circular economy are emerging, and some of them are already partially in place in the textiles industry

Based on the Ellen MacArthur Foundation's research on the theory and practice of system-level change and the experience of the Foundation from working with business and government on the transition to a circular economy – including the New Plastics Economy initiative³⁷ – some key characteristics that support system shifts have been identified:

- Alignment on the case for change
- A positive vision for a new system

- Broad stakeholder buy-in and time-bound commitments to a vision-led transformation
- Demonstration that the vision is possible, with large-scale, pre-competitive, cross-value-chain collaboration
- Unprecedented levels of collaboration and alignment in areas of action

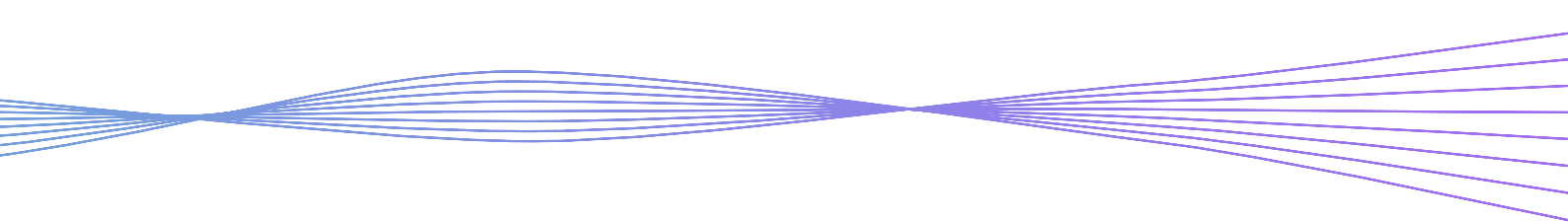
Research undertaken for this report, including numerous interviews with textiles industry experts, small and large brands, textile collectors, academics, and stakeholder workshops, concluded that many efforts are already being made by brands, retailers, and other organisations to change the industry. These efforts offer solutions and demonstrate promising progress in various areas, but are fragmented and often only effective at small scale. Ensuring the critical characteristics for system-level change are in place would harness this momentum and accelerate the transition.

Alignment on the case for change.

Transforming a system requires a great deal of effort and therefore a compelling rationale.

Together with other recent publications,³⁸ this report presents a clear need to change the current textiles system, capture economic opportunities and prevent potentially catastrophic outcomes. Crucially, Part I of this report reinforces the case for change at the systems level, identifying the current linear business model, with its low rates of utilisation (leading to high levels of throughput) and low levels of recycling, as a root cause of many issues of the current system.

A positive vision for a new system. By its very definition, system change entails moving from an existing system to a new one. This requires a positive vision of the system to move towards: “If we can imagine it, we can achieve it”.³⁹ The extent of the take-up of the circular economy framework – virtually unknown until just a few years ago – is an example of the power of such a positive vision to mobilise action.



Recently, various efforts have been made to identify the elements of a better textiles industry and this report presents for the first time a detailed vision of a new textiles economy based on the principles of a circular economy (see Part II).⁴⁰ This vision is distinct from, and complements, ongoing efforts to make the textiles system more sustainable by minimising its negative impacts. With specific emphasis on innovation towards a different system, a new textiles economy presents an opportunity for delivering substantially better economic, societal, and environmental outcomes.

Broad stakeholder buy-in and time-bound commitments to a vision-led transformation.

To achieve system change, buy-in to the vision needs to be built across different actors, including industry, government and cities, civil society, and the broader public. None of these groups can do it alone. In particular, ambitious, common, time-bound commitments to the vision are required.

The extent of ongoing activities in the textiles industry, both individual and multi-stakeholder, shows an increasing buy-in to the need to address the range of issues; many significant sustainability initiatives are gaining momentum. This report demonstrates the need to complement these with commitments towards the vision and ambitions of a new textiles economy. Such commitments would need to be made by industry leaders, for example major brands. While existing individual brand commitments are a first important step, concrete collaborative commitments towards this positive vision would be needed to deliver a step-change towards a more circular system. There are already efforts underway to get commitments to some of the ambitions of a new textiles economy. For example, the Global Fashion Agenda is gathering commitments to immediate action points for cycling clothes within the system, to be achieved by 2020.⁴¹ The Detox campaign by Greenpeace collected commitments to the phase-out of substances of concern.⁴²

Demonstration that the vision is possible, with large-scale, pre-competitive, cross-value-chain collaboration. Demonstrator projects, conducted collaboratively by various stakeholders along the value chain, are required to test new models at scale and provide evidence for their success. This is particularly

important, as no single actor can achieve system change alone.

No large-scale demonstration project representing the full extent of the vision currently exists, but there are promising small-scale efforts. One example of such a collaborative initiative is ‘ReLooping Fashion’ in Finland, which pilots a unique production experiment of cotton clothing recycling, and has developed a cross-value-chain business ecosystem in line with the principles of the circular economy.⁴³

Unprecedented levels of collaboration and alignment on areas of action. Various actions are needed to support the transition, including: a dialogue mechanism (involving the whole value chain and existing initiatives), an open evidence base, innovation for system solutions, informed enabling policy, and new industry standards and guidelines. These actions are interrelated and mutually reinforce each other. As such, the intended large-scale system change can only be achieved by orchestrating them in a coordinated manner.

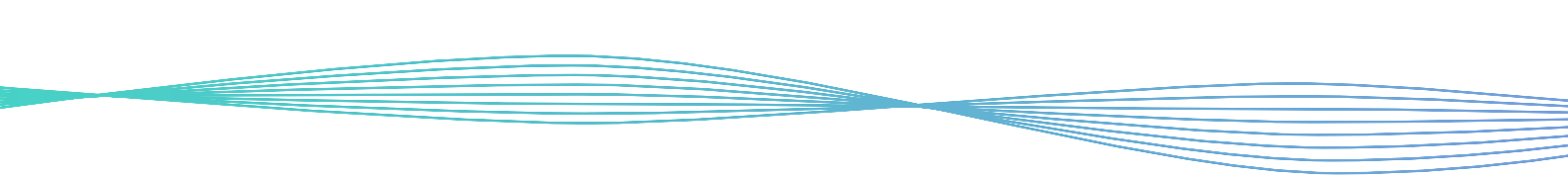
For the textiles industry, research to date has identified a large number of industry efforts aimed at enabling the transition. The main gap is not necessarily the lack of activity in any of these areas; rather it is coordination, alignment, and the deepening of the impact of existing initiatives. See Box A, p.30, for the areas of action to move towards a new textiles economy and existing industry efforts.

A new approach is needed to close gaps, reinforce current efforts, and unlock system-level change

The case for changing the textiles system is clear, and the vision proposed in Part II of this report represents an attractive target state. To reach unstoppable momentum towards a new textiles economy, the existing efforts to change the system should be consolidated by a new approach that would serve to:

1. ALIGN KEY INDUSTRY PLAYERS ON A CLEAR VISION AND SECURE THEIR COMMITMENT TO IT

Commitments of leading industry players towards the new vision and ambitious targets would enable more effective system-wide progress. New, aligned commitments,



together with a joint action plan to achieve them – covering all four ambitions of a new textiles economy and building as appropriate on existing initiatives – should consider, for example, targets on the phase-out of substances of concern and plastic microfibre release, quality and durability standards, requirements to design for recyclability, and minimum levels of recycled content in clothing.

2. DRIVE LARGE-SCALE, CROSS-VALUE-CHAIN DEMONSTRATOR PROJECTS

A new level of collaboration should be sparked by the undertaking of cross-value-chain demonstrator projects. Concrete collective actions, involving many brands working together pre-competitively, would in the short term initiate the transition and demonstrate progress. While further analysis is needed to identify what the most promising areas of these collective actions would be, examples include:

- Large-scale projects in major pilot cities, including several brands, city councils, collecting/sorting/reprocessing actors, jointly engaging the public in large-scale collection efforts, carried out as public-private initiatives, and realising the value of collected streams
- Joint implementation of common design and material selection standards or guidelines, developed as part of a pre-competitive collaboration between several designers, buyers, textile mills, and recyclers, taking into account all aspects of a new textiles economy, including durability, recyclability, the absence of substances of concern, and the minimisation of microfibre release
- Collaboration projects for implementing new business models at scale, jointly identifying barriers and pulling the levers to overcome them (e.g. new technologies, joint marketing, or informed public policy)

3. ORCHESTRATE COMPLEMENTARY INITIATIVES AND REINFORCE THEIR IMPACT

Orchestration should take place to steer existing and future key initiatives in such a way that they complement each other, to ensure that progress in the different areas of action (see Box A, p.30) is amplified, and that progress

towards one ambition does not impede progress towards another. A comprehensive mapping of ongoing activities is required to understand the landscape and to quickly identify not only gaps and barriers in any area of action, but also opportunities to spark high levels of collaboration. Monitoring and broadcast of new crucial findings surfacing from any area of action would reinforce each initiative's impact.

4. BROADLY ENGAGE STAKEHOLDERS AND ENSURE WIDE PROMOTION OF THE VISION

Further actions to more widely engage stakeholders along the textiles value chain and provide them with the relevant support, tools, and insights to progress towards the vision. Critical actions include:

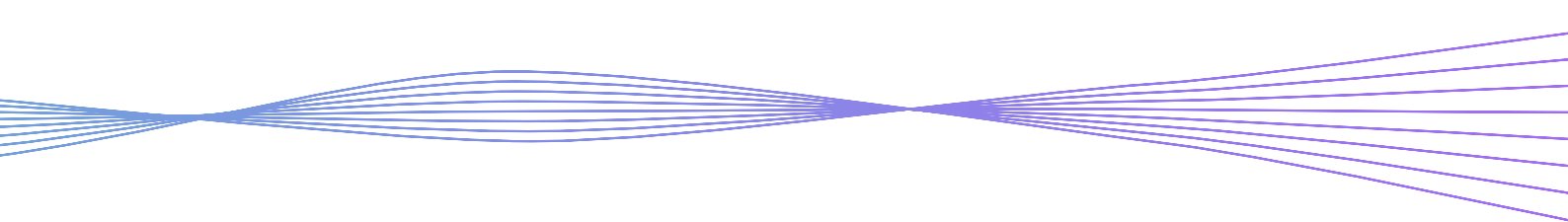
- Broadcasting evolving best practices and insights gained to stakeholders along the global textiles value chain
- Engaging policymakers and sharing of policy best practices
- Broadly communicating the nature of the current situation and the vision of a new textiles economy
- Continually involving additional actors in commitments

5. ESTABLISH A COORDINATING VEHICLE THAT TAKES ON THESE FOUR ACTIVITIES

To ensure a step change in industry mobilisation, an independent vehicle would need to be established to drive and coordinate the four activities of the new approach. It would need to be set up in a way that is complementary to, and value-adding for established programmes, convening the many stakeholders relevant for the transition.

Different organisations can contribute to the transition in their own unique ways

Businesses throughout the textiles value chain, policymakers at various levels, as well as other organisations, all have an important role to play in the transition towards a new textiles economy. Any approach to systemic change in the textiles system must recognise the unique roles of these



actors and engage them in the transformation. Alignment, collaboration, and coordination between them is critical to create large-scale change and overcome issues such as the lack of standards in certain areas and the absence of alignment between clothing design and what happens after their use.

Businesses are naturally placed to play a leading role in the transition. Businesses of all sizes throughout the textiles value chain – from big brands, through manufacturers and textile collectors, to small enterprises and innovators – can contribute to systemic change in the textiles system. In particular, brands and retailers are in a unique position, given that they are the ones who design and sell clothing in the first place. They can drive change through their visibility, global supply chains and power in the market. They have the ability to influence purchasing behaviour by changing their value proposition and using their strong marketing know-how. They also determine the pace of introduction of new products and the material composition of clothing. Clothing manufacturers and fibre producers are also crucial as so many of the system impacts occur during their activities. Businesses involved in collection, sorting, processing, refurbishing, and recycling can play a key role in developing the techniques and technologies to ensure that garments and materials stay within a closed-loop system, as well as in providing valuable feedback that can inform designers and manufacturers about what is needed to maximise value after use.

Policymakers at various levels can set direction for the transition and create the right enabling conditions. Cities and municipalities often control the after-use collection infrastructure and can be key partners in initiatives related to textile collection and processing. Policymakers are well positioned to contribute to the change through realigning incentives, connecting different players pre-competitively, influencing

aspects of design and standards in a positive way, and stimulating innovation. Setting the right policy can also support the transition in several ways (see Box A, p.32).

Education and research institutions can support the transition through embedding circular economy principles in their teaching and creating evidence and proof points.

Bringing circular economy principles into education, from school through to professional development, will equip learners with the systems-thinking skills and mindsets needed to become active shapers of a circular economy in general, and a new textiles economy in particular. Further research – at universities, other research institutions or in targeted initiatives and programmes – is needed to develop the evidence base for a new textiles economy and establish the best ways to implement it. Collaboration between researchers, businesses, and other relevant organisations is crucial, for example to address specific knowledge gaps identified in the market or to demonstrate feasibility through pilot projects.

Other organisations, including industry associations and initiatives, NGOs, and international bodies, also play important roles. Industry associations and initiatives could facilitate and foster collaboration among businesses across the value chain and create alignment between actors on the broad transition to a new textiles economy as well as on individual aspects of it. They connect stakeholders and could also help share information, case studies, best practices, and lessons learned. The involvement of NGOs and international bodies is required to ensure that broader environmental and societal considerations are taken into account in future solutions.

BOX A: AREAS OF ACTION TO MOVE TOWARDS A NEW TEXTILES ECONOMY

Analysis and research to date have identified areas of action with the potential to collectively realise the required impact. These enablers interact and mutually reinforce each other, and the large-scale systemic change intended can only be achieved by addressing them in a coordinated manner.

A ROBUST EVIDENCE BASE

To guide the transformation towards, and to evolve the vision of, a new textiles economy, a robust evidence base is needed to create transparency on the impacts of the system and to aid stakeholders in defining actions required to change the system. While this report, together with a number of other recent efforts, aims to provide initial answers, more research is required.

In addition to this, existing economic and scientific evidence needs to be consolidated and made readily accessible to stakeholders across the value chain, for example via a highly referenced open-source platform, to make it easier to make decisions in line with the principles of the new textiles economy. This would also highlight knowledge gaps and prompt different actors to undertake complementary research to bridge those gaps. Initial further studies could include:

Investigating customers' motives for using and buying clothes as well as the business models that can meet their needs

- Determining the size of the different market segments based on customer needs and desires, the opportunities for different models to satisfy them, and the current barriers to customer adoption to provide a starting point for business model transformation
- Undertaking research on the key criteria for assessing durability and quality that would drive customers' demand for quality
- Investigating the elements needed for innovative business models to confidently lead the way to increased clothing utilisation

Researching the optimal balance of collection and recycling systems

- Building a comprehensive understanding of the current landscape of informal recycling and collection activities
- Understanding local cultures and which collection infrastructures would succeed in different regions
- Further researching the barriers and opportunities for the recycling of cellulose-based fibres, as well as economically attractive options for the recycling of blended materials
- Investigating the most efficient logistics to return materials to processors, for example centralised vs localised solutions and the best mix of these

Better understanding the different actors in the textiles system and their interactions

- Creating a detailed overview of the different actors and their interactions, for example through a systems map
- Identifying key actors to create starting points for change
- Creating a better understanding of the specific stakeholders that need to act in consort to create large-scale change

Better understanding the economic, environmental, and societal impacts of substances of concern and microfibres in the ocean

- Developing a robust evidence base on the usage of chemicals, including the amount used, as well as identification of substances of concern and the impacts of these
- Exploring of the socioeconomic impacts of microfibres in the ocean
- Better understanding the root causes of the release of plastic microfibres from textile washing in order to inform innovations in textiles construction and to create materials fit for a circular system

Further understanding the relevance and value of cross-flows into other industries

- Conducting investigations into the viability of creating high-value cross-sector material flows that would allow multiple applications in different industries

Research is already underway in several of these areas. Some approaches aim to cover all aspects of the clothing system, such as Mistra Future Fashion with its mission to provide “research for systemic change in fashion – via closed loops and changed mindsets”.⁴⁴ WRAP has also undertaken extensive research into the efficiency of the textiles system with a focus on the UK.⁴⁵ Many other organisations are investigating individual aspects, such as Fashion Positive, which is focusing on “positive materials” for clothing,⁴⁶ or the European Outdoor Group Microfibre Consortium, which is looking at enhancing the evidence base on microfibres.⁴⁷

INNOVATION

A significant number of innovators exist today and brands are starting to engage with them in various ways. With a growing evidence base (see above), these innovators can be steered towards the vision of a new textiles economy. Two key actions should support future innovation:

Steer innovation investments towards the common vision. Innovators should be supported at all stages, whether at the initial concept stage or when launching to market. They should be guided in the right direction, and promising innovations should receive the financial support needed to achieve scale. Brands should be involved in defining which innovations are needed, mindful of the common vision.

Innovation could include, for example, the search for material flow opportunities from other industries as an input into clothing manufacturing; the development of patterns that generate no leftover fabric when manufactured; innovative collecting and sorting technologies; textile-to-textile chemical recycling technologies that are able to separate and extract polyester and cotton; or the development of garments that last but which adapt themselves to changing styles.

Mobilise large-scale, targetted ‘moonshot’ innovations. In areas where existing innovation is sparse but a significant impact could be expected, innovation ‘moonshots’ should be mobilised. Stakeholders from across the industry would gather and spark innovation. One area for such innovations could be the search for a ‘super-fibre’ with similar properties to mainstream ones, but suitable for a circular system, with no negative externalities.

Existing programmes are already supporting and steering innovation, such as Fashion for Good, an initiative supporting fashion innovators at various stages;⁴⁸ Fabric for Change, a global initiative by Ashoka and the C&A Foundation “to support innovators for a fair and sustainable apparel industry”;⁴⁹ or the H&M Global Change Awards, an innovation challenge run by the H&M Foundation, to seek innovations that can support fashion to become circular.⁵⁰



POLICY

Policies at supranational, national, regional, and city/municipality levels can support the transition. Policymakers should be engaged with the common vision and provided with the relevant tools, data, and insights related to textiles so that they can make informed decisions to support the industry in key areas.

Policies that set direction and show commitment. Clear policies and communication can encourage private and public investment in relevant research and business development. Advancing the transition requires a coherent focus and systematic approach, including integration of the ambitions of a new textiles economy into existing government initiatives. For example, policies could provide targets and strategies for substances of concern, microfibres, durability, or recyclability. Clear and binding policies, laid out as a roadmap, would provide the visibility needed to coordinate infrastructure development and investment planning. Existing efforts can be seen in the EU's Circular Economy Action Plan, adopted in 2015, with a package including long-term targets to reduce landfilling and increase recycling and reuse.⁵¹

Regulatory frameworks that enable transition and remove current policy barriers. Some current policies, typically focused on individual areas rather than taking a systemic view, cause unintended barriers to adopting circular economy models. Detailed analysis of regulations – conducted with businesses and other relevant stakeholders – could identify these barriers and provide a basis for recommending policy changes that support a new textiles economy. For example, policymakers could set targets or incentives for collection. They could, for example, create extending producer responsibility (EPR) schemes for textiles, such as that existing in France, obliging clothing companies to contribute to the recycling and waste management of the clothes they put on the market. New policies could remove barriers that are caused by the definition of used textiles as waste, or address barriers to trade, such as import or export bans. Policymakers can also play an important role in stimulating demand by incentivising the use of recycled materials and/or disincentivising the use of virgin materials.

Public procurement and infrastructure investments. As governments often control large budgets for procurement and infrastructure spending, acquiring textiles through new service models and directing infrastructure spend where it most supports a new textiles economy would not only have a clear impact but would also lead the way for the private sector to follow. For example, public procurement recommendations that support promising, scalable circular business models for textiles could help kick-start such models and stimulate their wider adoption in the market. Public procurement policies can also increase demand for recycled materials by specifying targets for recycled content in clothing used by the public sector. Focusing infrastructure investments on schemes such as integrated after-use collection systems and sorting and reprocessing facilities could support circular economy activity and investment by the private sector.



TRANSPARENCY

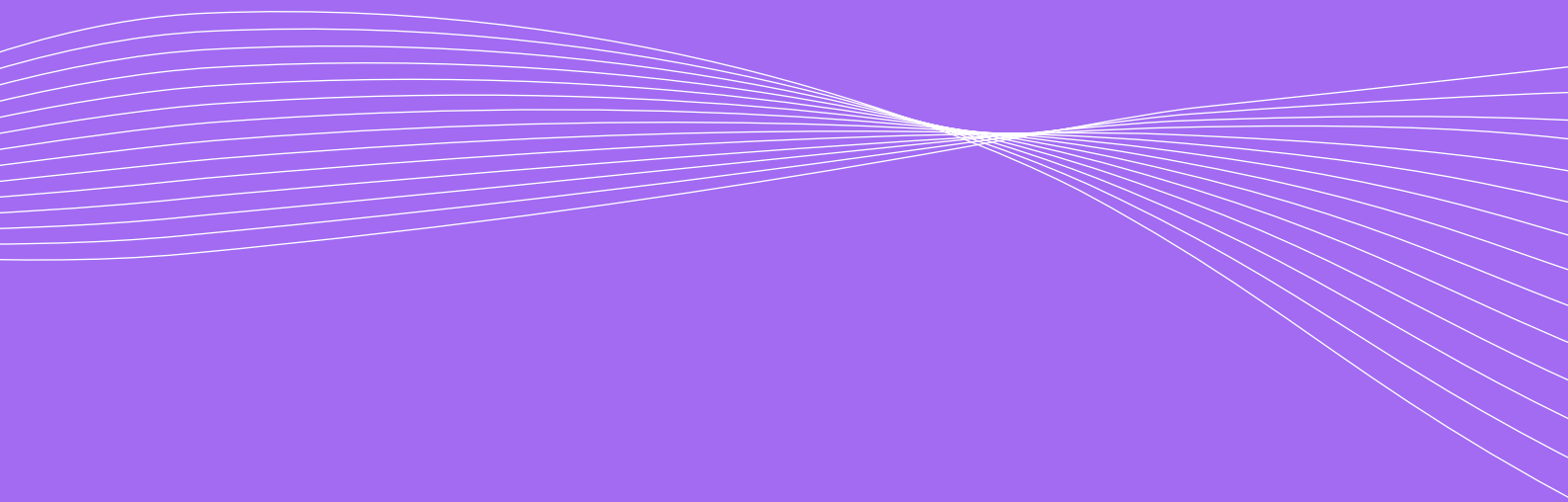
Transparency on a product's content, production history, and properties for use and after-use, for example information on substances of concern and resource use, durability and care information, or details on material content and recycling options is crucial to inform actions. Measurement tools, for example, can help assess products' content and the negative impacts of individual actors within the textiles industry, as well as their ongoing efforts to transform their practices for a new textiles economy. The Sustainable Apparel Coalition, for example, is contributing to this with the Higg Index.⁵²

MARKETING

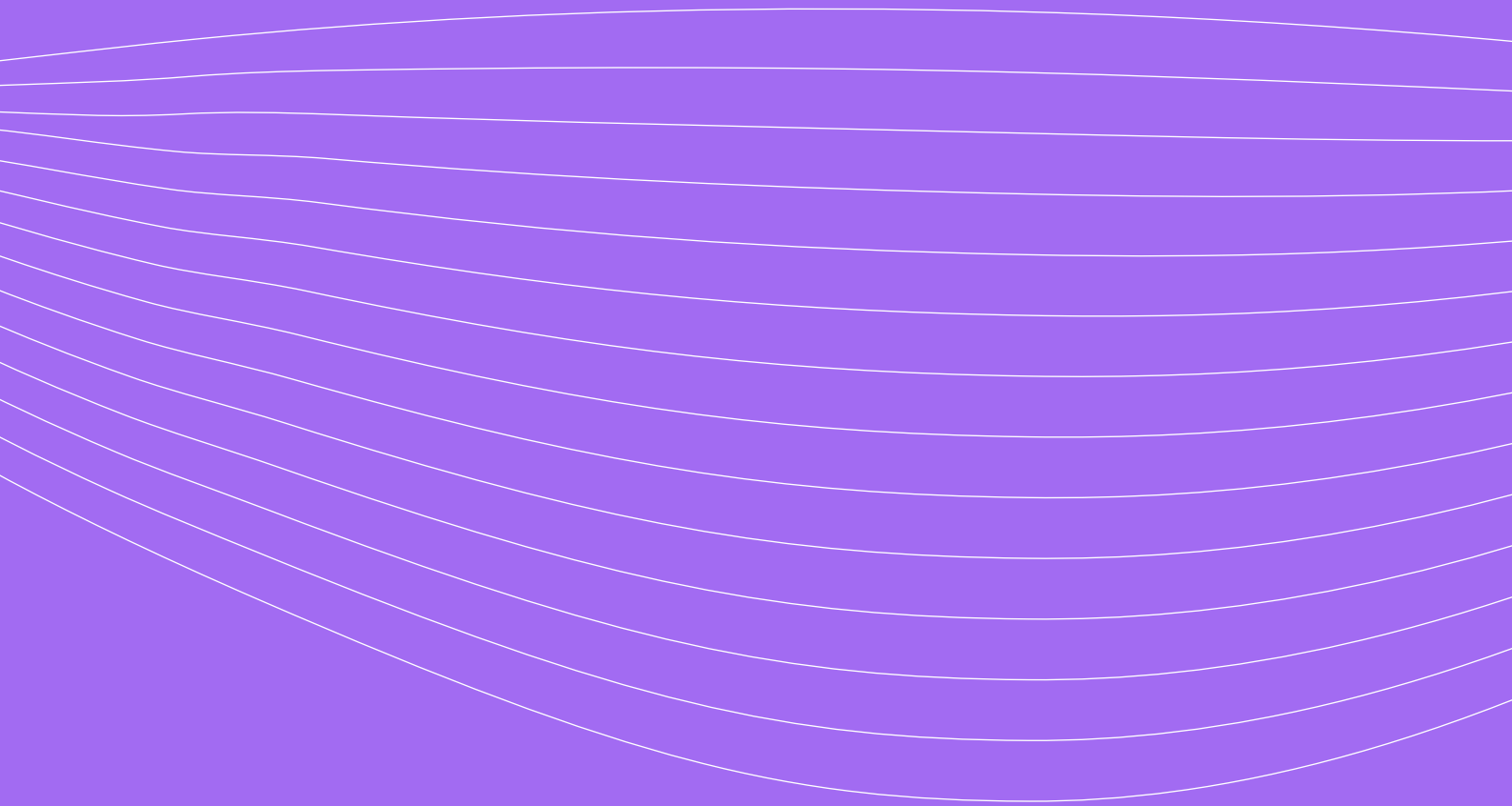
Implementing a new textiles economy depends upon customers embracing alternative models of accessing clothing. With their vast experience in marketing traditional sales, and great expertise and capacity, brands are in a good position to market new models as an attractive and fashionable option.

CIRCULAR-ECONOMY-DRIVEN INTERNAL STRATEGIES

Taking maximum advantage of circular models requires decision makers throughout organisations to appreciate the benefits of a circular economy and take these into account in business decisions. To put the ambitions of a new textiles economy into practice, current and prospective employees need training to better understand the aspects and advantages of circular economy models in general, and a new textiles economy in particular. In addition, the right incentives need to be in place to take the ambitions of a new textiles economy into account in business decisions.



PART I: THE CASE
FOR RETHINKING
THE GLOBAL
TEXTILES SYSTEM,
STARTING WITH
CLOTHING



PART I: THE CASE FOR RETHINKING THE GLOBAL TEXTILES SYSTEM, STARTING WITH CLOTHING

Textiles and clothing are a fundamental part of everyday life and an important sector in the global economy. As production volumes have doubled over the past 15 years, clothing is now a USD 1.3 trillion global industry employing more than 300 million people along the value chain.⁵³ Yet, the current system for producing, distributing, and using clothing operates in an almost completely linear way – wasteful and polluting. Money is being left on the table: more than USD 500 billion in value is lost from the system every year due to under-utilised clothes and the lack of recycling. As demand for clothing grows, systemic risks are already emerging and the current industry trajectory is set to have catastrophic consequences. Today’s negative impacts on resources, the environment, and people could become a significant risk to the industry’s future profitability.

The current clothing system is extremely wasteful and polluting

The current system for producing, distributing, and using clothing operates on a predominantly take-make-dispose model. High volumes of non-renewable resources are extracted to produce clothes that are often used for only a short period, after which the materials are largely lost to landfill or incineration. It is estimated that more than half of ‘fast fashion’ produced is disposed of in under a year.⁵⁴ This linear system leaves economic opportunities untapped, puts pressure on resources, pollutes and degrades ecosystems, and creates significant societal impacts at local, regional, and global scales.

Clothing is massively underutilised

Currently, customers purchase more clothing than they will use and are quick to throw garments away after use. Worldwide, clothing utilisation – the average number of times a garment is worn before it ceases to be used – has decreased by 36% compared to 15 years ago.⁵⁵ While utilisation is relatively high in low-income countries, elsewhere rates are much lower. For example, in the US clothes are worn

around a quarter as long as the global average. The same pattern is emerging in China, where clothing utilisation has decreased by 70% over the last 15 years (see Box G, p.77).

Underutilisation of clothing presents a significant opportunity to capture value.

Globally, customers miss out on USD 460 billion of value each year by throwing away clothes that they could continue to wear,⁵⁶ and it is estimated that some garments are discarded after just seven to ten wears.⁵⁷ People are acknowledging this as a problem – with, for example, 60% of German and Chinese citizens admitting to owning more clothes than they need.⁵⁸

After clothing is used, almost all the value in the materials they are made from is lost

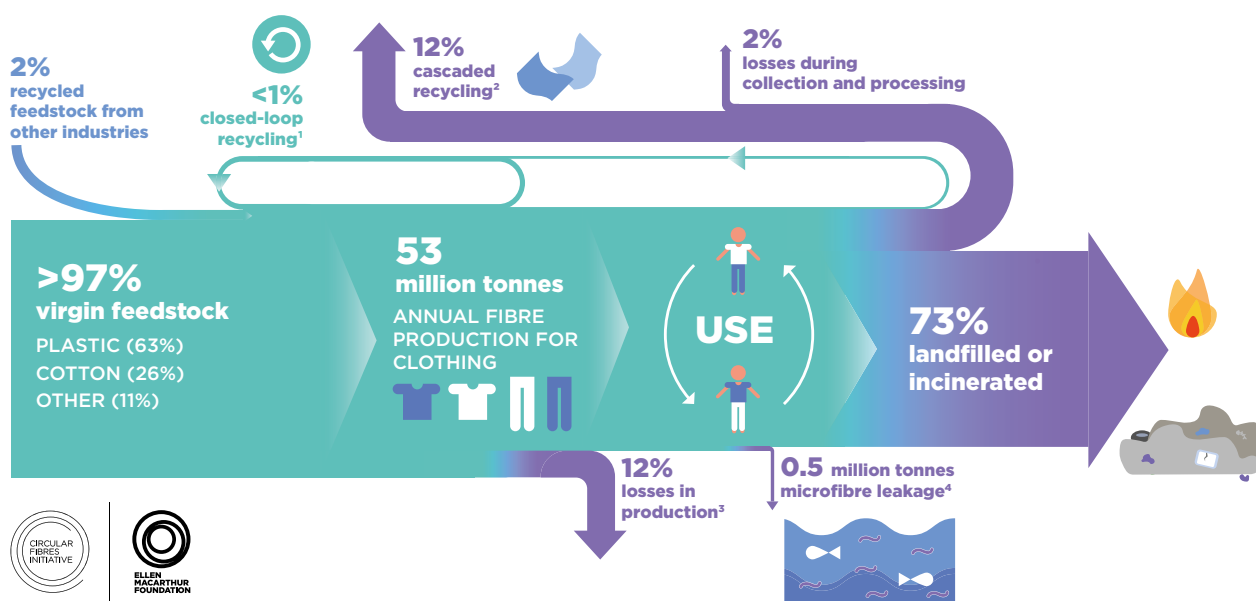
Of the total fibre input used for clothing, 87% is landfilled or incinerated, representing a lost opportunity of more than USD 100 billion annually.⁵⁹ As much as 73% of material going into the clothing system is lost after final garment use, 10% is lost during garment production (e.g. as offcuts)⁶⁰ and 2% is sent to landfill or incineration from garments that are produced, yet never make it to market. An additional 2% loss occurs in the collection and

sorting of discarded clothing (see Figure 6). Overall, one garbage truck of textiles is landfilled or incinerated every second.⁶¹ In addition to these significant value losses, high costs are associated with the disposal of clothing. For example, New York City alone spends more than USD 20 million a year landfilling and incinerating textiles, most of which constitutes clothing,⁶² and the estimated cost to the UK economy of landfilling clothing and household textiles each year is approximately GBP 82 million (USD 108 million).⁶³

Less than 1% of material used to produce clothing is recycled into new clothing. This includes recycling clothing after use, as well as

the recycling of factory offcuts. For recycling after-use clothing, expert interviews and some reporting suggest that the figure could be below 0.1%.⁶⁴ This rate is even lower than for other industries that are commonly identified as having low recycling rates, such as the single-use plastic packaging industry where the figure is around 2%.⁶⁵ Only 13% of the total material input is in some way recycled after clothing use. The majority of this recycling consists of cascading into lower-value applications such as insulation material, wiping cloths, and mattress stuffing. After being used in these applications, currently, the materials are difficult to recapture and therefore are usually discarded.⁶⁶

FIGURE 6: GLOBAL MATERIAL FLOWS FOR CLOTHING IN 2015



- 1 Recycling of clothing into the same or similar quality applications
- 2 Recycling of clothing into other, lower-value applications such as insulation material, wiping cloths, or mattress stuffing
- 3 Includes factory offcuts and overstock liquidation
- 4 Plastic microfibres shed through the washing of all textiles released into the oceans

Source: Circular Fibres Initiative analysis – for details see Appendix B

After-use clothing collection varies globally and most garments collected for reuse in countries with high collection rates are ultimately also lost from the system. Globally, around 25% of garments are collected for reuse or recycling through a variety of systems.⁶⁷ There are large regional differences in collection rates – in Germany 75% of discarded garments are collected,⁶⁸ while in the US and China rates are between 10% and 15%.⁶⁹ Many countries, particularly in Asia and Africa, have no collection

infrastructure at all. This is especially relevant as clothes collected for reuse in high-income countries are mainly exported to these parts of the world. These valuable efforts increase clothing utilisation, though ultimately most of these clothes end up in landfills or are cascaded to lower-value applications.⁷⁰

Today's linear system uses large amounts of resources and has negative impacts on the environment and society

With its low rates of utilisation (leading to high levels of throughput) and low levels of recycling, the currently wasteful, linear system has numerous negative environmental and societal impacts. It leads to substantial and ever-expanding pressure on resources and causes high levels of pollution. Hazardous substances affect the health of both textile workers and the wearers of clothes, and plastic microfibres are released into the environment, often ending up in the ocean. Furthermore, the materials currently used have significant drawbacks, making them unfit for a circular system. For example, polyester uses large quantities of non-renewable resources and fossil energy to produce, and growing cotton requires high volumes of fertilisers and pesticides (unless farmed using regenerative agriculture), as well as significant volumes of water. These, and other commonly-used materials, all have various negative impacts for people and the environment, leaving room for significant innovation in materials (see Appendix A for details).

The textiles industry is highly reliant on non-renewable resources across all stages of the value chain. The industry relies on 98 million tonnes in total of non-renewable resources per year. Producing plastic-based fibres for textiles uses an estimated 342 million barrels of oil every year,⁷¹ and the production of cotton is estimated to require 200,000 tonnes of pesticides and 8 million tonnes of fertilisers annually.⁷² Chemicals used in the production processes for fibres and textiles, such as dyes or finishing treatments, also account for a significant amount of resource use – around 43 million tonnes in total.⁷³

Hazardous chemical use has negative impacts across all parts of the value chain. Significant volumes of chemicals are used to produce clothing and other textiles. There is little data or transparency about which chemicals used cause concern or their full impact on human health and the environment during the production, use, and after-use phases. Cotton production uses 2.5% of the world's arable land, but accounts for 16% of all pesticides used;⁷⁴ in India 50% of all pesticides are used for cotton production,⁷⁵

with negative impacts on farmers' health.⁷⁶ The Citarum River in Indonesia has over 200 textile factories along its banks; these factories release dyes and other chemicals into the water, changing the colour of the river and devastating the local ecosystem.⁷⁷ Chemicals used in production may be retained in the finished textiles, causing concern about their impact on the wearer, and released into ecosystems during washing or when discarded after use. Often, this impact is not well assessed. For example, to achieve crease-resistant 'non-iron' garments, clothing is often treated with formaldehyde⁷⁸ – which has been classified as carcinogenic to humans by the International Agency for Research on Cancer, and is also linked to allergic contact dermatitis.⁷⁹ Other potential impacts to human health include the accumulation of toxic substances in the human body through exposure to polluted water or food sources.⁸⁰

Textiles production accounts for significant greenhouse gas emissions. The industry's immense footprint extends beyond the use of raw materials. In 2015, greenhouse gas (GHG) emissions from textiles production totalled 1.2 billion tonnes of CO₂ equivalent,⁸¹ more than those of all international flights and maritime shipping combined.⁸² This is mainly due to the high amounts of throughput in the current linear system, but it is also exacerbated by the high GHG intensity of textiles, with the production of 1 tonne of textiles generating 17 tonnes of CO₂ equivalent (compared to 3.5 tonnes for plastic and less than 1 tonne for paper).⁸³ GHG emissions during the use phase of textiles are also significant. Washing and drying clothing alone are estimated to account for 120 million tonnes of CO₂ equivalent.⁸⁴

Water use is high, often in water-scarce areas. Textiles production (including cotton farming) uses around 93 billion cubic metres of water annually, representing 4% of global freshwater withdrawal.⁸⁵ Clothing accounts for over two-thirds of this water use. At present, many of the key cotton-producing countries are under high water stress, including China, India, the US, Pakistan, and Turkey.⁸⁶ In China, 80% to 90% of fabric, yarn, and plastic-based fibres are made in water-scarce or water-stressed regions.⁸⁷ Beyond production, washing clothing using washing machines is estimated to require an additional 20 billion cubic metres of water per year globally.⁸⁸

Production of cellulose- and protein-based fibres competes for agricultural land.

The growing global population is increasing competition for productive land and freshwater resources. Cotton production currently accounts for 2.5% of the world's arable land.⁸⁹ Similarly, wool has a high land impact – estimated by DEFRA to be as much as 278 hectares per tonne of fibres (compared with just over 1 hectare per tonne for cotton).⁹⁰ The increasing demand for land for food production could significantly limit any possible expansion of land-intensive cotton- or wool-related agriculture in the future and so restrict the output of these fibres.⁹¹

During textile use, trillions of plastic microfibres are released through washing; most of these ultimately end up in the ocean.

Plastics entering the ocean is a growing concern due to the associated negative environmental and health implications. In recent years, plastic microfibres from the washing of plastic-based textiles, such as polyester, nylon, and acrylic, have been identified as a major contributor to this issue.⁹² Each year, around half a million tonnes of plastic microfibres – equivalent to more than 50 billion plastic bottles – resulting from the washing of textiles are estimated to be released into the ocean.⁹³

The industry also has multiple negative societal implications, driven partly by the increasing pressure on manufacturers to deliver on shorter lead times and lower pricing.

High cost and time pressures are often imposed on all parts of the supply chain,⁹⁴ which can lead to garment workers suffering poor working conditions with long hours and low pay,⁹⁵ with evidence, in some instances, of modern slavery and child labour.⁹⁶ Efforts to improve these conditions are facing various challenges; for example, the right to establish trade unions is restricted.⁹⁷ Many workers face dangerous working environments due to hazardous processes, substances of concern used during production, unsafe buildings, or lack of safety equipment. Local communities, while benefitting from employment in the industry, may also suffer from poor environmental practices; for example, some factories discharge untreated production wastewater, polluting local rivers used for fishing, drinking, or bathing.⁹⁸

The trajectory of the industry points to the potential for catastrophic outcomes

Demand for clothing continues to grow quickly, driven particularly by emerging markets in Asia and South America. Should growth continue as expected, total clothing sales could reach 175 million tonnes in 2050 – more than three times today's amount.⁹⁹ This would further amplify the negative societal and environmental impacts of the current system and risk the industry's reputation and profitability.

Negative impacts could become unmanageable

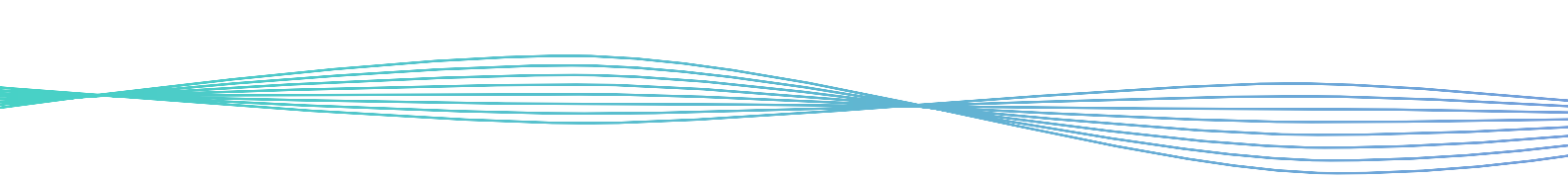
If the industry continues on its current path, by 2050, textiles production would use more than 25% of the carbon budget for a 2°C pathway.¹⁰⁰ Moving away from today's linear and wasteful textiles system is therefore crucial to keeping the current target of a 2°C average global warming limit within reach.

The number of plastic microfibres entering the ocean between 2015 and 2050 could accumulate to an excess of 22 million tonnes.

The release of plastic microfibres into the ocean due to the washing of textiles could grow to 0.7 million tonnes per year by 2050. This would be the material equivalent of around 4 billion polyester tops.¹⁰¹ The accumulated amount entering the ocean between 2015 and 2050 would exceed 22 million tonnes – about two thirds of the plastic-based fibres used to produce garments annually.

Material and water usage is set to become increasingly problematic. Input of fossil feedstocks for textiles production would reach 160 million tonnes by 2050. With water usage, the greatest challenge will be accessing the water that the textiles industry relies on in water-scarce regions. This has been identified by investors as a high risk for business disruption and potential for stranded assets.¹⁰²

Management of textile waste would become increasingly challenging. In the business-as-usual scenario, more than 150 million tonnes of clothing would be landfilled or burned in 2050.



Between 2015 and 2050 the weight of these clothes would accumulate to more than ten times that of today's world population.¹⁰³

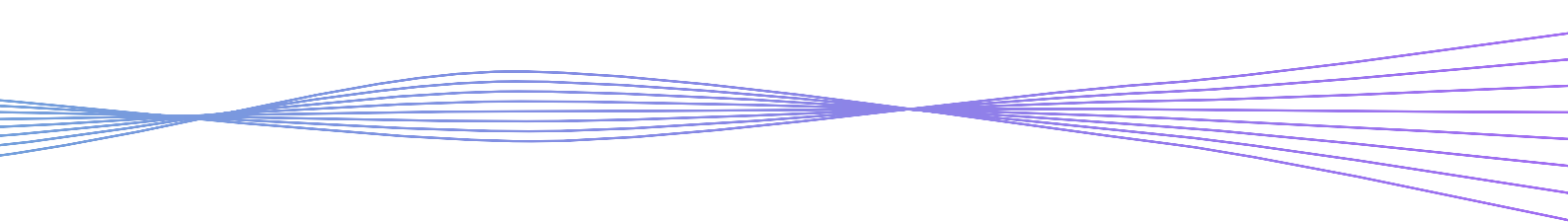
Profitability of the industry could be at risk

Maintaining current clothing production and approaches risks the profitability of the textiles industry. The recent *Pulse of the fashion industry* report projects that by 2030, fashion brands could see a decline in earnings before interest and tax (EBIT) margins of more than three percentage points. This would translate into a profit reduction of approximately EUR 45 billion (USD 52 billion) for the industry.¹⁰⁴ The report also estimates that the overall benefit to the world economy would be about EUR 160 billion (USD 192 billion) in 2030, if the fashion industry would successfully address environmental and social issues.¹⁰⁵

The negative impacts of the industry have the potential to increase reputational risks for brands and regulatory trends, both affecting

the profits of businesses that fail to respond.

The negative environmental impacts described above, together with high-profile social incidents like the Rana Plaza disaster in 2013, in which over 1,000 workers were killed,¹⁰⁶ have drawn international attention to the societal impacts associated with the clothing value chain. NGOs are also generating awareness of the industry's negative environmental and societal impacts. For example, Greenpeace has highlighted specific challenges – such as the use of substances of concern in clothing, through their Detox campaign¹⁰⁷ – and, recently, has challenged the industry to find systemic solutions to tackle 'overconsumption', moving beyond downstream, short-term approaches to reduce the industry's impact.¹⁰⁸ In another example, Fashion Revolution has created a campaign driving awareness of the way clothes are made, with their Fashion Revolution Week calling on people and organisations to work together to “radically change the way clothes are sourced, produced, and consumed”.¹⁰⁹



PART II: A NEW TEXTILES ECONOMY IS AN ATTRACTIVE VISION OF A SYSTEM THAT WORKS

The overarching vision of a new textiles economy is that it is aligned with the principles of a circular economy: one that is restorative and regenerative by design and provides benefits for business, society, and the environment. In such a system clothes, textiles, and fibres are kept at their highest value during use and re-enter the economy after use, never ending up as waste.

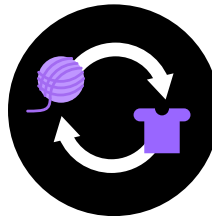
Realising this vision of a new global textiles system relies on four core ambitions: phasing out substances of concern and microfibre release; transforming the way clothes are designed, sold and used to break free from their increasingly disposable nature; radically improving recycling by transforming clothing design, collection, and reprocessing; and making effective use of resources and moving to renewable input.

A new textiles economy is based on the principles of a circular economy (see Box B, p.48). Such a system would have the following characteristics:



A new textiles economy produces and provides access to high-quality, affordable, individualised clothing.

In a new textiles economy, everyone has access to the clothes that they need, when they need them. New business models allow more flexibility on which clothes to wear and when, as well as provide access to clothes that might not be affordable through traditional sales. Clothes are designed and produced to provide high quality, durability, and flexibility – for example in the form of individualised or modifiable clothes.



A new textiles economy captures the full value of clothing during and after use.

In a new textiles economy clothes are used more often, allowing their value to be captured fully. Once clothes are not used anymore, recycling them into new clothes allows the value of the materials to be captured at different levels (see Figure 17, p.95). For this to be successful, no substances of concern that could contaminate products and prevent them from being safely recycled are used.



A new textiles economy runs on renewable energy and uses renewable resources where resource input is needed.

The energy required to fuel a new textiles economy is renewable by nature, decreasing resource dependence and increasing system resilience. Resources are kept in the system and where input is needed, this comes from renewable resources. This means using renewable feedstock for plastic-based fibres and not using fossil-fuel-based fertilisers or pesticides in the farming of biologically-based input. A new textiles economy further enables this shift to renewables as its very nature ensures that less energy and fewer resources are consumed.



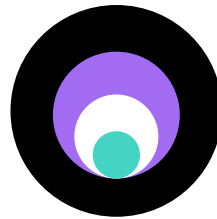
A new textiles economy regenerates natural systems and does not pollute the environment.

In a new textiles economy, where renewable resources are extracted from nature this is carried out by regenerative and restorative methods that allow for the maintenance or improvement of soil quality and rebuild natural capital. In particular, this means using regenerative agriculture for biological-based input such as cotton, and sustainably managed forests and plantations for wood-based fibres. Substances of concern do not leak into the environment or risk the health of textile workers and clothing users. Plastic microfibres are not released into the environment and ocean. Other pollutants, such as greenhouse gases, are also designed out.



A new textiles economy reflects the true cost (environmental and societal) of materials and production processes in the price of products.

In a new textiles economy, the price of clothing reflects the full costs of its production, including environmental and societal externalities (see Section 4.2). Such costs are first analysed and presented in company reporting, and ultimately reflected in product prices.



A new textiles economy is distributive by design.

As part of promoting overall system health, a new textiles economy presents new opportunities for distributed and inclusive growth. It creates a thriving ecosystem of enterprises from small to large, retaining and then circulating enough of the value created so that businesses and their employees can participate fully in the wider economy.



A new textiles economy could bring substantial benefits

The business benefits of a circular economy are well understood,¹¹⁰ and its opportunities for high-income countries (especially in Europe),¹¹¹ as well as emerging economies have been explored.¹¹² In addition to offering benefits to business and the economy, a circular economy is beneficial to citizens and society, and it regenerates the environment.¹¹³ The research undertaken for this report indicates that, given the global size and impact of the textiles sector, a new textiles economy could play a major role in providing such benefits. Detailed modelling and analysis would be needed to quantify the full range and size of the benefits that a new textiles economy could bring.

Benefits for businesses and the economy

Material cost savings and reduced exposure to resource price volatility. A new textiles economy would significantly lower the costs to businesses of using virgin materials. Decreased material use would also reduce businesses' exposure to volatile raw material prices and thereby increase their resilience. Realising these benefits for the textiles industry is dependent on radically increasing the amount of clothing that gets recycled by improving the current recycling system (Ambition 3).

Additional profit opportunities for businesses through new services. Introducing new rental and subscription models allows businesses to build long-term customer relationships. These alternatives to the traditional sales model for clothes would allow fashion brands to create profits without having to increase throughput, and open up opportunities for innovators to trial new business models. In addition, value would be created through enhanced resale as well as by offering additional services before and during use, such as individualisation, warranties, and maintenance (Ambition 2).

Greater opportunity to manage reputational risks and align with policy priorities. The negative environmental and societal impacts of the industry (see Part I) are increasingly leading to reputational risks for brands and to action by regulators. These trends have the potential

to jeopardise the profits of businesses seen as laggards in addressing the shortcomings of the current system. By moving towards a new system with positive outcomes, brands would be better able to avoid negative exposure and to work collaboratively with policymakers towards common goals.

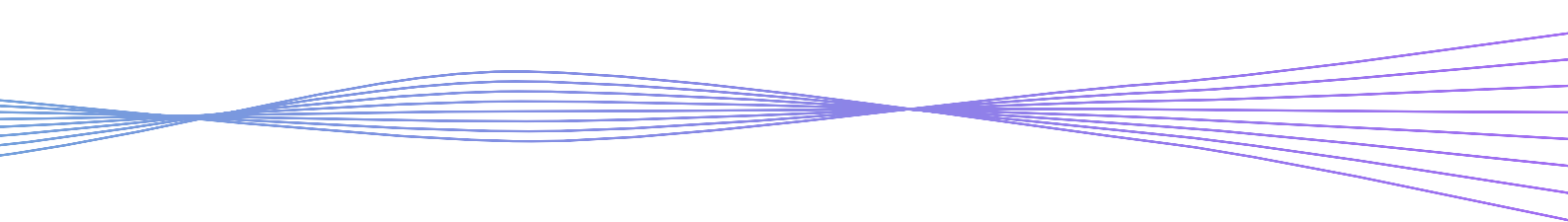
A new source of innovation. The vision of a new textiles economy – creating clothing that by design circulates in a system that maintains its value – is a powerful spur for new ideas that would redirect the focus of innovators. These innovations would help the textiles system to become more circular, by developing new and improved materials, processes, and services.

Additional economic growth. A new textiles economy means growing the most restorative and regenerative parts of the value chain, particularly those that make more productive use of material inputs (mainly through higher rates of clothing utilisation and recycling of materials) and increase revenue from new circular activities. While some sectors (e.g. the production of virgin materials and certain clothing production activities) could expect reduced revenue, overall income would be expected to increase, which could boost economic growth.

Quantifying these impacts for the textiles industry would require detailed modelling of the effects on GDP of the various actions proposed. This analysis would have to quantify the associated opportunity costs and value of avoided negative externalities, while also considering potential 'rebound' effects that lower costs of the textiles system might have for other industries.¹¹⁴

Benefits for the environment

Lower GHG emissions. A new textiles economy would significantly reduce the industry's GHG emissions. For example, if on average the number of times a garment is worn were doubled, then GHG emissions would be 44% lower (Ambition 2), while textiles made from recycled materials have lower emissions than those made from virgin materials (Ambition 3). Using low-carbon materials and production processes (including renewable energy and energy-efficiency measures) would further reduce the GHG emissions of a new system (Ambition 4).



Reduced consumption of virgin, non-renewable materials and of energy. The extraction of virgin materials for plastic-based fibres, the use of pesticides and fertilisers in cotton production, and the production of energy from non-renewable sources all have significant negative environmental impacts, such as GHG emissions, and the leaking of substances of concern and other pollutants into local environments. A new textiles economy with high rates of clothing utilisation, improved recycling, and reduced waste in production would reduce all these impacts.

Increased land productivity and soil health. A new textiles economy would apply regenerative agricultural methods to the production of cotton and other renewable materials used in textiles production. This would increase land productivity and return nutrients to the soil. These efforts would enhance the value of land by increasing the organic matter in the soil.

Less plastic in the ocean. Plastics in the ocean are increasingly considered a substantial problem to which the washing of plastic-based textiles is a significant contributor (see Box F, p.67). A new textiles economy would ensure that textiles, and the system that uses them, are designed to prevent the release of plastic microfibrils into the environment and, ultimately, the ocean.

No leakage of hazardous substances into the environment. In a new textiles economy, substances of concern would be phased out, reducing the negative impacts of polluted wastewater and soil, and the accumulation of hazardous substances in the environment (see Section 1.1). Circulating products through increased utilisation and improved recycling also reduces the quantity of textiles landfilled or burned – both of which often lead to the leakage of substances of concern.

Reduced pressure on water in water-scarce regions. A new textiles economy with increased rates of clothing utilisation and recycling would reduce the amount of water needed for new materials and products, avoid water-intensive activities in water-scarce regions, and reduce water use by employing efficiency measures.

Benefits for citizens and society

Greater utility and choice with lower overall costs for customers. The additional choice and quality provided by new sales and service models in a new textiles economy would enhance the benefit experienced by customers. Choice increases as businesses create clothes and related services that better meet customer needs. Although detailed analysis is needed to estimate the effects of a new textiles economy on the cost of providing clothing, the overall cost to produce the same level of benefit from clothing is expected to be lower in a new textiles economy.¹¹⁵

Reduced obsolescence and fewer unwanted items. A new textiles economy would provide benefits to different types of customers. Longer-lasting and higher-quality clothes would increase convenience for those customer groups and types of garments for which clothes shopping and/or maintenance is considered a hassle. New models of providing access to clothes would leave those who desire frequent outfit changes with fewer items that are soon no longer wanted (Ambition 2).

Positive health impacts. In a new textiles economy, safe and healthy material inputs into textiles production would not leave workers exposed to substances hazardous to their health, and would reduce health risks for everyone wearing clothes. The negative health impacts of pollution, for example increased rates of cancer or allergic reactions from exposure to chemicals, would also be reduced in a new textiles economy.¹¹⁶

A better deal for employees. Because a circular economy is distributive by design, value would be circulated among enterprises of all sizes in the industry, rather than being extracted. This would allow all parts of the value chain to pay workers well and provide them with good working conditions.

BOX B: CIRCULAR ECONOMY CONCEPT AND PRINCIPLES

THE CONCEPT OF A CIRCULAR ECONOMY

Looking beyond the current take-make-dispose extractive industrial model, a circular economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural, and social capital. It is based on three principles:

- **Design out waste and pollution**
- **Keep products and materials in use**
- **Regenerate natural systems**

In a circular economy, economic activity builds and rebuilds overall system health. The concept recognises the importance of the economy needing to work effectively at all scales – for large and small businesses, for organisations and individuals, globally and locally.

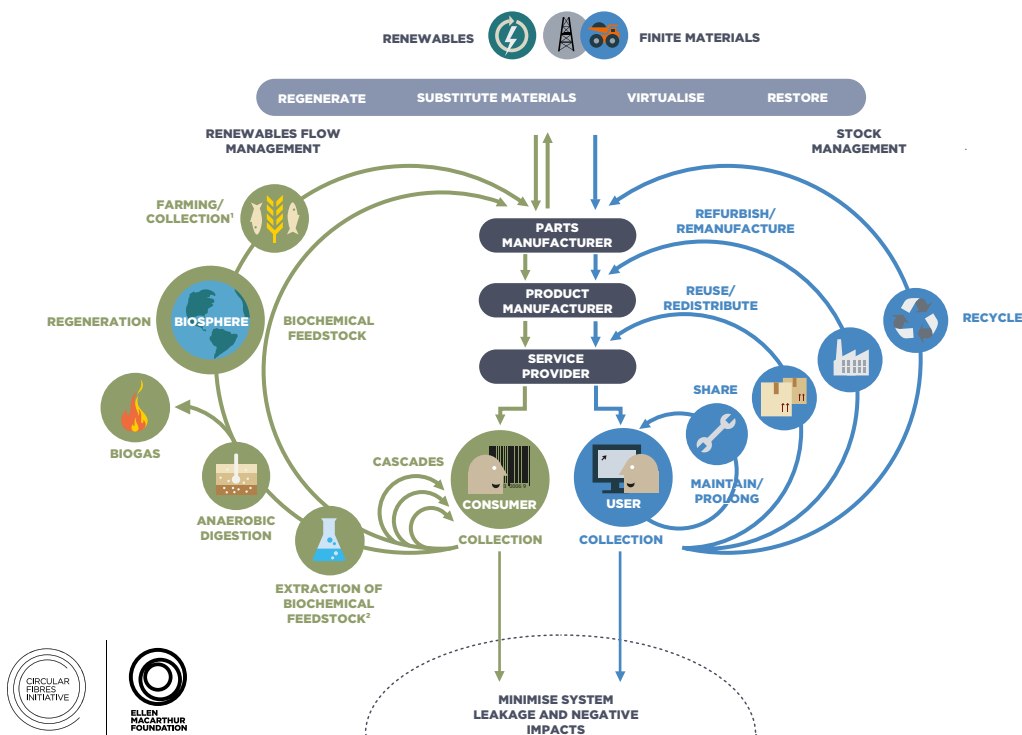
Transitioning to a circular economy does not only amount to adjustments aimed at reducing the negative impacts of the linear economy. Rather, it represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits.

The model distinguishes between technical and biological cycles. Consumption happens only in biological cycles, where food and biologically-based materials (such as cotton or wood) are designed to feed back into the system through processes like composting and anaerobic digestion. These cycles regenerate living systems, such as soil, which provide renewable resources for the economy. Technical cycles recover and restore products, components, and materials through strategies like reuse, repair, remanufacture or (in the last resort) recycling (see Figure 7).

The notion of circularity has deep historical and philosophical origins. The idea of feedback, of cycles in real-world systems, is ancient and has echoes in various schools of philosophy. It enjoyed a revival in industrialised countries after World War II when the advent of computer-based studies of non-linear systems unambiguously revealed the complex, interrelated, and therefore unpredictable nature of the world we live in – more akin to a metabolism than a machine. With current advances, digital technology has the power to support the transition to a circular economy by radically increasing virtualisation, dematerialisation, transparency, and feedback-driven intelligence.

The circular economy model synthesises several major schools of thought. They include the functional service economy (performance economy) of Walter Stahel; the Cradle to Cradle design philosophy of William McDonough and Michael Braungart; biomimicry as articulated by Janine Benyus; the industrial ecology of Reid Lifset and Thomas Graedel; natural capitalism by Amory and Hunter Lovins and Paul Hawken; and the blue economy systems approach described by Gunter Pauli.

FIGURE 7: CIRCULAR ECONOMY SYSTEM DIAGRAM



1 Hunting and fishing

2 Can take both post-harvest and post-consumer waste as an input

Source: Ellen MacArthur Foundation, drawing from Braungart & McDonough, Cradle to Cradle (C2C)

THE PRINCIPLES OF A CIRCULAR ECONOMY

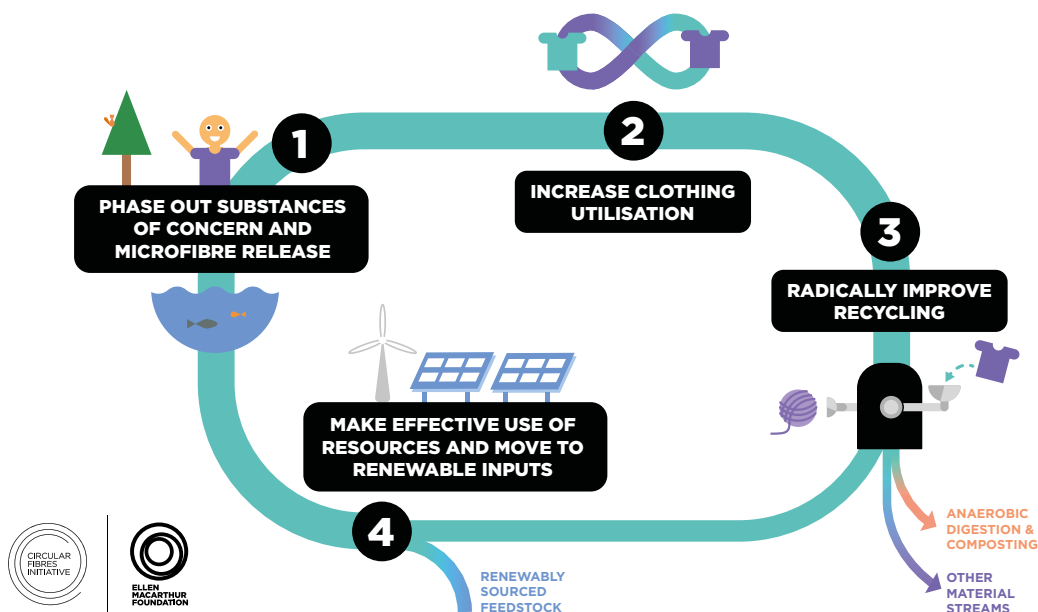
The circular economy model rests on three principles. Each addresses several of the resource and system challenges that the textiles system is facing today or might face tomorrow.

Design out waste and pollution. A circular economy reveals and designs out the negative impacts of economic activity that cause damage to human health and natural systems. This includes the release of greenhouse gases and hazardous substances, the pollution of air, land, and water, as well as structural waste such as traffic congestion.

Keep products and materials in use. A circular economy favours activities that preserve more value in the form of energy, labour, and materials. This means designing for durability, reuse, remanufacturing, and recycling to keep products, components, and materials circulating in the economy. Circular systems make effective use of biologically-based materials by encouraging many different uses before nutrients are returned to natural systems.

Regenerate natural systems. A circular economy avoids the use of non-renewable resources and preserves or enhances renewable ones, for instance by returning valuable nutrients to the soil to support regeneration, or using renewable energy as opposed to relying on fossil fuels.

FIGURE 8: AMBITIONS FOR A NEW TEXTILES ECONOMY



A new textiles economy requires new and ambitious thinking

A new textiles economy has four main ambitions (see Figure 8) that are consistent with the principles of a circular economy (see Box B). These ambitions aim to bring about a new textiles economy by rethinking the existing textiles economy and capturing opportunities missed by its current, linear nature.

- 1. Phase out substances of concern and microfibre release**
- 2. Transform the way clothes are designed, sold, and used to break free from their increasingly disposable nature**
- 3. Radically improve recycling by transforming clothing design, collection, and reprocessing**
- 4. Make effective use of resources and move to renewable inputs**

These ambitions are discussed in detail in the following chapters. Action towards meeting them needs to take a coordinated and systemic approach, making sure that progress in one area does not impede progress in another.

Ambition 1 is essential to fulfil the first principle of a circular economy: designing out waste and pollution. Ambitions 2 and 3 apply the second principle of a circular economy: keeping products and materials at their highest value. Increasing clothing utilisation takes advantage of the innermost loops in a circular economy (see Figure 7), thereby keeping clothes at their highest value. Once they are not used anymore, recycling retains the value of the materials at different levels (see Figure 17, p.95). Ambition 4 is related to all principles of a circular economy: a new textiles economy designs out waste during textiles production, uses resources effectively and efficiently, and moves towards using renewable resources in a regenerative manner.

Realising these ambitions will not happen overnight. While there are some immediate profit opportunities for individual businesses, collaborative efforts across the value chain and spanning the private and public sectors, are required to truly transform the way clothes are designed, produced, sold, used, and reprocessed. Such a requirement should not discourage or delay action. The time to act is now and the ambitions discussed in the following four chapters offer an attractive target state for the industry to align on and innovate towards.

BOX C: BIOLOGICAL CYCLES IN A NEW TEXTILES ECONOMY

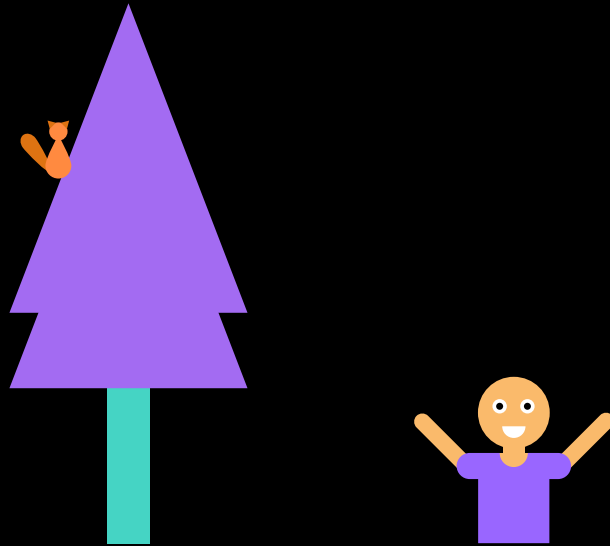
In a circular economy, value is retained in either biological or technical cycles (see Figure 7). Hardly any clothes produced today, however, are made purely from biodegradable or bio-benign materials, meaning that biological cycles are not an option for most clothes. Because of this, Ambitions 2 and 3 for a new textiles economy focus on value creation in technical cycles, through increasing the rates of clothing utilisation and different levels of recycling. Regardless, it is not unthinkable that, in the future, innovation in new materials and processes could allow clothes to be created that are suitable for biological cycles via composting and anaerobic digestion.¹¹⁷

Cellulose-based fibres are naturally biodegradable. However, even garments made purely from biodegradable materials often contain other materials in stitching, labels, or buttons etc. (see Box I, p.94). Additionally, dyes contained in clothes are not necessarily safe if they leak into the environment, and clothes often contain residues of other chemicals used in fibre production and textiles processing (see Section 1.1). The presence of substances of concern can also hinder composting. For example, heavy metals can inhibit the bacterial growth essential to the process or contaminate the compost, thereby reducing its nutritional value.¹¹⁸

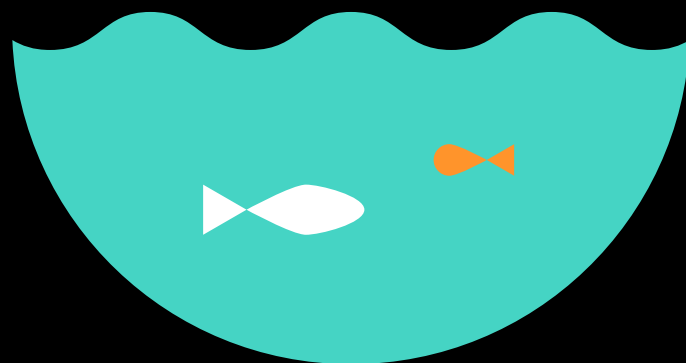
Examples are emerging of clothes being designed that are completely biodegradable. For example, C&A has developed a Cradle to Cradle Certified T-shirt made purely from organic cotton, including the stitching, that is treated with safe materials and chemicals, as well as non-toxic dyes – allowing the T-shirt to be fully composted if it can no longer be worn or recycled (see Case Study A, p.64). Another example is the company Freitag, which produces jeans with a button that can be unscrewed by hand so that non-biodegradable parts can be removed easily.¹¹⁹

Even for garments that are biodegradable, practical hurdles might prevent biodegrading at large scale. When clothing is collected, systems would be needed to keep compostable items separate from non-compostable items; private end-of-use composting relies on households having access to home-composting systems. Even if these drawbacks could be overcome, the high resource and energy intensity of the current clothing production methods (see Part I), means that a large amount of value is lost when clothes are composted rather than recycled. Also, the actual nutrient value that can be restored to the soil is low for textiles. For example, cotton has very low nitrogen, phosphorus, and potassium content.¹²⁰

High levels of innovation are needed to make biodegradable clothing a viable option at scale. Opportunities could lie in very fast-growing plants that need low amounts of treatment and water combined with processes that need less resource input. Research is already underway. In a project with clothing brand Filippa K, Mistra Future Fashion is investigating design approaches for “short-life garments”, which includes new material samples. By looking at these “short-life garments” intended for ultra-fast textiles, as well as “long-life garments”, the project aims to find the most suitable choice for different types of garments and their respective intended duration of use.¹²¹



1. Phase out substances of concern and microfibre release



1. PHASE OUT SUBSTANCES OF CONCERN AND MICROFIBRE RELEASE

First and foremost, in a new textiles economy material input would be safe and healthy to allow it to cycle in the system and avoid negative impacts during the production, use, and after-use phases. This means that substances which cause concern to health or the environment are designed out and no plastic microfibres are released into the environment and ocean.

Actions are needed in two areas to phase out substances of concern and microfibre release. The first is to align industry efforts to create safe material cycles in order to scale up the use of existing alternative technologies. The second is to develop new materials and production processes that prevent the release of plastic microfibres, while simultaneously increasing the effectiveness of technologies that capture unavoidably released microfibres.

1.1. Align industry efforts and coordinate innovation to create safe material cycles

Many of the chemicals used to make clothing and other textiles bring substantial advantages, including water or stain repellence, increased durability, or a wide choice of colours. Yet a number of these chemicals raise concerns due to their potential adverse effects during clothing production, use, and after-use phases. Indeed, some have been found to be carcinogenic or hormone disruptive, causing concern for the health of factory workers exposed to them, and for the environment into which they escape, for example by being released into local rivers in factory effluent. The World Bank estimates that 20% of industrial wastewater pollution worldwide originates from the textiles industry.¹²² Some of these substances are bio-accumulative and classified as persistent, meaning that once in the environment, they

will remain there for a long time.¹²³ Despite growing concerns raised by NGOs, the public, policymakers, and across the textiles value chain itself, there is very low transparency on the chemicals used across the industry, making the true scale of the pollution – and its associated economic, environmental, and societal impacts – difficult to evaluate.

Significant opportunity exists for the industry to capture value by creating safe material cycles while addressing the devastating health and pollution impacts of textiles production. Businesses that move quickly to address the issues associated with substances of concern can avoid costs associated with the use of such substances, including correct storage and handling, measures to protect employee health, handling of hazardous waste, and the cost of environmental remediation if these substances leak out.¹²⁴ Three key actions could support the creation of safe material cycles: aligning existing industry efforts to harmonise standards and improve transparency; driving collective innovation efforts to develop and scale safe alternative chemicals and production processes; and moving to regenerative agriculture.

1.1.1. THE RISKS AND COSTS ASSOCIATED WITH SUBSTANCES OF CONCERN ARE MOTIVATING STAKEHOLDER ACTION

The production of textiles currently requires intensive use of chemicals, including substances of concern.^{125,126} Annually, 43 million tonnes of chemicals are used to produce textiles.¹²⁷ The textile chemicals market is significant in its own right, valued at USD 21 billion in 2015 – around one-sixth of the total sales of the clothing industry – and is expected to reach USD 29 billion by 2024.¹²⁸ Chemicals are used at several stages – from fibre production, to dyeing, treating, and finishing processes – and often to give specific properties to the items. More details on the most common functions of chemicals used in textiles production and processing are given in Box D.

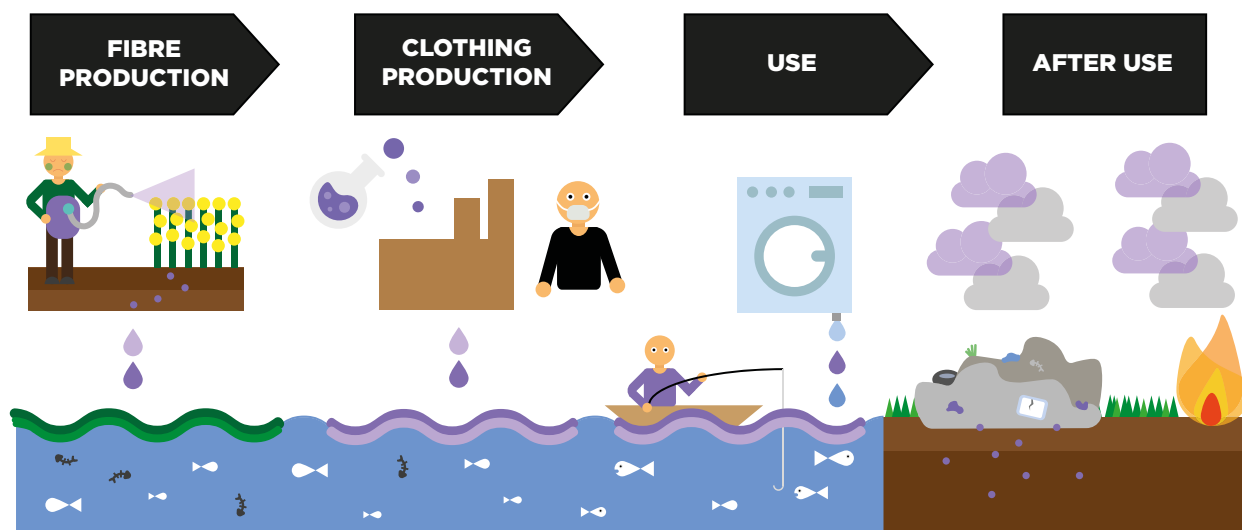
Substances used at all stages of the production process often remain in textiles, both intentionally and unintentionally.¹²⁹ This raises concerns due to the adverse effects they can have on people and the environment (see Figure 9). Reported impacts range from allergic reactions, to respiratory diseases and increased instances of cancer in humans, to the loss of aquatic life.¹³⁰ Some of the chemicals used also persist in the environment and accumulate over time.¹³¹ Box E discusses some of the known impacts of substances of concern during different phases of the textiles value chain.

More evidence is needed on the effects of chemicals used, in order to inform sourcing choices across the supply chain and to eliminate the leakage of substances of concern into the environment. It is estimated that over 8,000 different chemicals are used to turn raw materials into textiles.¹³² While a number of

important impacts of some textile chemicals have been identified, this represents just a few of the chemicals currently being used. A significant number of chemicals, however, have not been evaluated for their impacts, meaning that their risks are unknown.¹³³ For instance, the production of polyester often uses antimony trioxide as a catalyst, which is retained in the polyester fibres.¹³⁴ Antimony trioxide is suspected of causing cancer in humans if inhaled,¹³⁵ but the impact on human health from wearing polyester garments has not yet been evaluated conclusively.¹³⁶

The phase-out of substances of concern can have various economic benefits. The management of substances of concern is costly, particularly where the use of chemicals is strongly regulated, for example through special storage and transportation requirements, personal protection measures for workers, or wastewater treatment measures. Businesses could also find themselves exposed to remediation costs if substances of concern leak out into the environment.¹³⁷ Increasing global regulation on unsafe chemical use could see these costs increase wherever textiles are produced, and manufacturers should anticipate facing such costs in the future. The first movers to phase out substances of concern may increase competitiveness by avoiding such costs and gaining technical knowledge on alternatives. The overall economic benefits of phasing out substances of concern are difficult to assess due to low transparency on chemical use or data on employee-related health impacts. The *Pulse of the fashion industry* report estimates that eliminating today's negative health impacts due to poor chemicals management in the industry would have an economic benefit of EUR 7 billion (USD 8 billion) annually in 2030.¹³⁸

FIGURE 9: SUBSTANCES USED IN TEXTILES RAISE CONCERNS ABOUT ADVERSE EFFECTS DURING THE PRODUCTION, USE, AND AFTER-USE PHASES



Eliminating substances of concern is needed to capture the full value of a closed-loop system.

Rapidly eliminating substances of concern from textiles production is required to enable healthy flows of materials in a circular system, along with methods to remove those that remain in circulation from existing textiles. During recycling, the presence of substances of concern has the potential to disrupt the recycling process and leads to the continued circulation of – and therefore exposure to – these substances, depending on the recycling methods used.¹³⁹ This is already a challenge that is seen in recycling today, as textiles which were placed on the market before current regulations, can contain significantly higher amounts of certain substances of concern than virgin materials, where the use of these substances is restricted.¹⁴⁰ This makes the material value more difficult to recapture. The presence of certain toxic substances, such as heavy metals, can also hinder composting, for example, by inhibiting the bacterial growth essential to the process or by contaminating the compost, thereby reducing its nutritional value.¹⁴¹

International attention is being drawn to the environmental and health impacts of substances of concern used in the textiles industry, causing reputational risks to companies.

Businesses working proactively to address the shortcomings of the current system – and anticipating upcoming regulations – can reduce risks to their reputation, and, consequently, to profits. There has already been a significant industry shift, driven by increasing demands for transparency on the environmental costs of dyes and other chemicals used in the textiles industry from NGOs, governments, and customers pressurising players along the value chain to act. For example, following Greenpeace’s Detox campaign, around 80 companies, including fashion brands, large retailers, and textiles suppliers, have committed to the ZDHC programme to achieve greater transparency and zero discharges of hazardous chemicals in their supply chain by 2020.¹⁴²

BOX D: KEY CHEMICALS USED IN TEXTILES PRODUCTION AND PROCESSING (ADAPTED FROM CHEMSEC¹⁴³)

Pesticides. Pesticides are used to defend crops from damage by insects, mould, or weeds. Residues of pesticides may therefore be present in cotton where they are used during farming. While a number of hazardous pesticides (e.g. mirex, endosulfan, and dichlorodiphenyltrichloroethane (DDT)) have been banned globally by the Stockholm Convention,¹⁴⁴ many are still applied to cotton crops in some countries.¹⁴⁵

Solvents. Solvents are used in large quantities at various stages of textiles production to dissolve substances such as dye pigments. Many are hazardous when inhaled or if they come into contact with the skin. Solvents are used in the production of cellulose-based fibres (to extract and treat the cellulose). The viscose process, in particular, often uses carbon disulphide which has been linked to numerous severe health conditions.¹⁴⁶

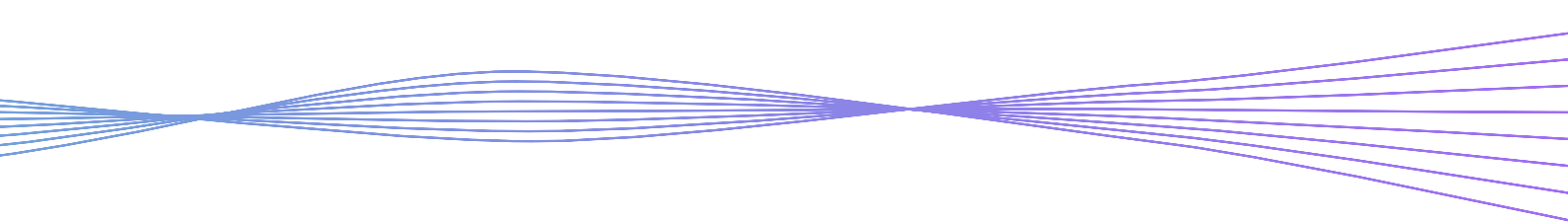
Surfactants. Surfactants may act as detergents, wetting agents (enabling easier absorption into the material), emulsifiers, foaming agents, dispersants, softeners, and anti-pilling and anti-static agents. They are used in many stages of the production process. Commonly used surfactants include alkyl phenol ethoxylates, which are problematic because they can be metabolised, resulting in substances that are endocrine disruptors, meaning they could interfere with the hormone systems of mammals and fish.

Dyes and pigments. Dyes and pigments are used to colour clothes. Some frequently used dyeing methods apply dyes in excess quantities, with large amounts being discharged into wastewater. Some dyes, including amine-containing azo dyes, are persistent, which is a desired property in fabric but not in the environment. Dyes also sometimes contain heavy metals such as lead or cadmium. Under certain conditions, some dyes break down into carcinogenic compounds and others can cause allergic reactions.¹⁴⁷

Plasticisers. Plasticisers are used to soften plastics, such as polyvinylchloride (PVC). In textiles, PVC is used for screen-printing designs and coating fabrics. One common group of plasticisers is the phthalates, which are used in large quantities in printing. Several phthalates have hazardous properties, including being harmful to hormonal systems and reproductive health. As phthalates are not chemically bound to the PVC used for image printing, they can leak out when worn or washed. Because of this, EU legislation, for example, bans the use of certain phthalates.¹⁴⁸

Water and stain repellents. Water repellence is often a desired property, especially for textiles to be used outdoors. A popular way to achieve this is by impregnating the fabric with fluorinated or perfluorinated compounds. Some of these substances contain unintended impurities, such as perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS).¹⁴⁹ These are persistent in the environment, have the ability to bioaccumulate, and are now found even in remote regions.¹⁵⁰

Studies have shown that these have hormone-disrupting properties with impacts on the reproductive and immune systems.¹⁵¹ Many companies are taking action to phase out these substances, yet by doing so, they often increased the use of other perfluorinated substances with a slightly different chemical structure but similar properties. For example, the alternative perfluorohexanoic acid (PFHxA) has also been found to persist in the environment.¹⁵²



Flame retardants. Flame retardants are used to make a product less flammable. Depending on national regulations, flame retardants may be required in certain products. Examples include protective clothing, curtains, and fabrics used in furniture. Some currently used flame retardants, especially halogenated versions, have been shown to possess hazardous properties. Perfluorohexane sulfonate (PFHXS), which is used as a flame retardant, has been recommended for inclusion on the EU's Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) list for restriction, due to its strong persistence and its potential to bioaccumulate in the human body.¹⁵³

Biocides. Biocides are used to prevent living organisms from thriving on clothes during storage or transport, and to give anti-odour properties to products such as sportswear. These are designed to be hazardous for the target organisms, making it a challenge to develop biocides that do not harm other organisms, including humans. Some of them, such as mould protection, can contaminate the areas where warehouse and store personnel unpack clothing and textiles, as they can be released when the packaging is unwrapped. Problematic biocides that may be contained in final textile products include triclosan, triclocarban, and nano-silver. Increasingly, concern is being raised about the possibility that bacteria can develop resistance to the released antibacterial substances and that this can trigger the development of resistance to antibiotics.¹⁵⁴

BOX E: SUBSTANCES USED IN FIBRE MANUFACTURING AND TEXTILES PROCESSING RAISE CONCERNS ABOUT ADVERSE EFFECTS DURING THE PRODUCTION, USE, AND AFTER-USE PHASES OF THE TEXTILES VALUE CHAIN

IMPACTS DURING FARMING AND FIBRE MANUFACTURING

Production of cellulose-based fibres requires a large amount of chemicals, of which a number cause concern. Despite accounting for 2.5% of agricultural land globally, the production of cotton accounts for as much as 16% of all pesticides used.¹⁵⁵

Chemicals used in the production of cotton cause serious damage to the environment and have negative health impacts on farmers, with repeated cases of acute poisoning from pesticides.¹⁵⁶ The production of cotton also accounts for 4% of nitrogen and phosphorus fertiliser use globally, which can lead to water pollution by running off the land and into rivers, encouraging algal blooms that starve the river of oxygen.¹⁵⁷

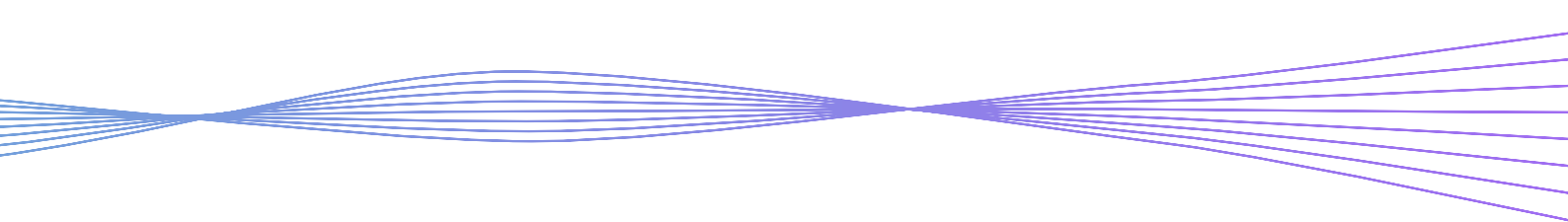
Heavy chemical use is involved in making other cellulose-based fibres, in particular viscose. The processes used to make these fibres extract cellulose from trees or other plants using a variety of process-specific chemicals.¹⁵⁸ Without correct handling, this can cause significant problems for factory workers through direct exposure, and chemicals have been found to be released in large quantities into rivers in Asia.¹⁵⁹ For example, viscose production uses sodium hydroxide, which is corrosive, and direct contact can cause skin burns and eye damage.¹⁶⁰ In the production of viscose, the extracted cellulose is then spun into fibres using carbon disulphide, which has a number of health impacts, and, due to its volatility, easily escapes into the factory during processing. Reported impacts for workers include neurological and vascular symptoms.¹⁶¹ When leaked into water, pollutants from the process present a high risk of acute aquatic toxicity, a single exposure incident can result in the death of aquatic organisms.¹⁶²

Manufacturing of plastic-based fibres poses threats to human health through substances used or emitted during the manufacturing process.¹⁶³ The manufacture of nylon, for example, releases nitrous oxide, a strong greenhouse gas that also depletes ozone.¹⁶⁴ Antimony trioxide is a commonly-used catalyst in the production of polyester. Where this chemical is discharged untreated through factory wastewater, it can cause harm to a range of aquatic organisms.¹⁶⁵

IMPACTS DURING TEXTILES PRODUCTION

Various chemicals are used in textiles production, in particular for pre-treating, dyeing, washing, printing, and fabric finishing. Factory workers without personal protection equipment are often exposed to these and sometimes these chemicals are also discharged into rivers in wastewater from production facilities.¹⁶⁶

The Swedish Chemicals Agency (KEMI) reviewed more than 2,400 substances used in clothing manufacturing and found that approximately 30% of the identified substances posed a risk to human health, and 10% of these were functional chemicals. Functional chemicals are intended to provide a specific function or appearance to the textile, such as dyes, and are expected to remain in finished articles in significant concentrations, for example, azo dyes.¹⁶⁷ Some azo dyes have properties associated with an increased risk of cancer and developmental defects, or are associated with an increased risk of allergy.¹⁶⁸



The Citarum River in Indonesia, frequently reported as “the most polluted river in the world”,¹⁶⁹ is an infamous example of the effects that a heavy concentration of textile manufacturers, not adequately treating their factory wastewater, can have. The hundreds of textile factories along the river’s banks have released lead, mercury, and other chemicals into the waters.¹⁷⁰ Samples taken of effluents from one of the many facilities in the area found the presence of a number of hazardous chemicals, including nonylphenol, antimony, and tributylphosphate. Water discharged from the specific facility was found to be highly alkaline, which could cause burns to human skin, and have a fatal impact on aquatic life.¹⁷¹ In the last few decades more than 60% of fish species living in the river have died out, causing local residents to shift from fishing to collecting plastic debris on the surface to make a living.¹⁷²

IMPACTS DURING USE

Substances of concern are not only released into the environment during textiles production, but can stay on the fabric, causing potential adverse effects during use. As garments are washed, chemicals that remain on them from production can be released into wastewater or transported on microfibres which are shed and end up in the environment.¹⁷³ This impact is amplified as microfibres can accumulate high concentrations of substances of concern on their surface, and can be consumed by marine organisms.¹⁷⁴

Examples of such pollutants include perfluorinated chemicals (PFCs), which have been found to affect the liver and kidneys and act as endocrine disruptors;¹⁷⁵ organotins, which impact human development, the immune system, and the nervous system;¹⁷⁶ and nonylphenol ethoxylates (NPEs). NPEs are widely used as surfactants and detergents in textiles processing, they are toxic to aquatic life, persist in the environment, and can accumulate in body tissue and in the food chain.¹⁷⁷

Despite regulation in some countries and regions, such as the EU, banning the use of NPEs in textiles production, imports of clothing from countries with no regulation on NPEs have been found to be contaminated by these chemicals. NPEs can break down into nonylphenol, which is a priority hazardous substance to eliminate under the EU Water Framework Directive due to its negative impacts on aquatic life.¹⁷⁸ The UK Environment Agency calculated that the washing of such clothing accounted for 173 kilograms of NPE emissions into water bodies in the UK during 2011, an average of 8 milligrams of NPE per kilogram of textiles.¹⁸⁰ 99.9% of the NPE was reported to be washed out in the first two washes. Nonylphenol tends to accumulate in the tissues of plants and animals and has also been shown to have the potential to disrupt hormones. Exposure to nonylphenol may therefore interfere with breeding patterns and the reproductive success of animals.¹⁸¹

Some PFCs used for water and stain repellence degrade slowly or not at all, while others will transform into persistent substances, such as PFOA and PFOS (see Box D). These are classified as “persistent, bioaccumulative, toxic” PFCs, and cause concern when they are released into the environment through washing.¹⁸²

IMPACTS AFTER USE

After use, the large majority of textiles end up in landfill or incineration. Substances of concern that are contained in the textiles, such as any remaining dyes or chemicals that have been introduced during production or use, can leak out of the textiles as they degrade into the environment.¹⁸³ KEMI estimates that the degradation of textiles in landfills accounts for the release of over 2,000 tonnes of hazardous colourants in the EU each year.¹⁸⁴ If the waste is incinerated without controlling emissions, the combustion gases also have the potential to release substances of concern.¹⁸⁵

1.1.2. ALIGN EXISTING INDUSTRY EFFORTS TO HARMONISE STANDARDS AND IMPROVE TRANSPARENCY

Widespread adoption of collaborative industry-led practices that phase out substances of concern could create rapid momentum towards a new textiles economy, since shared supply chains mean that this change cannot be driven by one brand alone.

Aligning efforts towards an ambitious common target state could more rapidly scale adoption of restricted substances lists (RSLs), manufacturing restricted substances lists (MRSLs), and voluntary standards. High industry fragmentation and low transparency on the chemicals used to produce textiles create a number of challenges in addressing the use of substances of concern. Improving transparency across the supply chain would enable better sourcing decisions and help phase out the most polluting substances. To support the shift to a new system, there is a need for a greater evidence base, especially where the impacts of some chemicals used are unknown. Innovation towards alternative, non-hazardous processes for producing textiles is also crucial. Policymakers will need to play a role to accelerate the transition, and the nature of this role needs to be explored.

Align restricted substances lists to rapidly phase out the most harmful substances

Substances identified as being of the highest concern should be eliminated from the system as a priority. There is growing awareness of the issues surrounding substances of concern, which has led to the creation of RSLs – thresholds in the concentration of certain chemicals that are not allowed to be exceeded in finished products. Larger brands often have their own RSLs,¹⁸⁶ and additional substances are restricted by policymakers through legislation, such as the EU's REACH legislation.¹⁸⁷ MRSLs go a step further to restrict the use of specific chemicals above a certain threshold concentration from being used at all in the manufacturing process.

Manufacturers across the value chain are having to deal with varying criteria from different sources, which can slow down the progress of phasing out the most polluting chemicals. For

example, textile mills that supply a variety of retailers struggle to change chemical inputs between batch runs.¹⁸⁸

Harmonisation and adoption of a common RSL and MRSL could more rapidly eliminate the most hazardous substances, by simplifying the requests placed on manufacturers. This would have the added benefit that for smaller brands and retailers, the manufacturers would likely retain the same MRSL. The Zero Discharge of Hazardous Chemicals (ZDHC) programme has started this process and created a common MRSL for the textiles industry, which has been adopted by a group of signatories including major brands, and textile and chemical manufacturers.¹⁸⁹ The Apparel and Footwear International RSL Management (AFIRM) Group provides a forum to advance the global management of restricted substances in apparel, and has a common RSL. Many well-known brands and retailers are members of AFIRM.¹⁹⁰ Including manufacturers in harmonisation efforts would support the implementation of changes.

A comprehensive, transparent, and systematic screening approach needs to be taken to derive RSLs/MRSLs. It is important that joint efforts do not lead to the shortest RSL/MRSL on which everyone can agree. Additionally, taking a grouping approach on adding substances to the list (e.g. all PFCs) would avoid substances from a similar chemical family, and with similar environmental or health implications, being used as substitutions to remain compliant with RSLs/MRSLs. Brand commitments to common lists created by independent organisations and experts could be key to avoiding these problems.

Drive industry-led commitments towards guidelines to identify where to focus innovation efforts

Clear guidelines for chemicals that can be used safely, with relevant information on functional characteristics, costs, and ecotoxicological information, could empower brands and retailers to make better sourcing decisions, and in return increase demand for non-hazardous alternatives. This would also help identify gaps where innovation is needed to provide the desired functionality.

The Better Cotton Initiative (BCI), which seeks “to make global cotton production better for the people who produce it, better for the



environment it grows in and better for the sector's future", has demonstrated the speed at which industry-led commitments can effect change. In 2010, BCI cotton accounted for 3.6% of all cotton produced globally; by 2016 this had increased to 12%. BCI had 986 members by the end of 2016, representing brands, cotton suppliers, clothing manufacturers, and cotton producer organisations.¹⁹¹

Improve transparency on substances used in production processes

Brands demanding and publicly reporting full transparency on all inputs to their clothing can more quickly eliminate the use of substances of concern. Brands that build strong relationships with their suppliers can improve trust and therefore information sharing on chemical use, ensuring confidence in their supply chain. Currently, chemical suppliers are not required to specify the exact ingredients of their chemicals, such as the composition of dyes. In a 2016 report by KEMI, among the more than 3,500 chemical substances identified as potentially used in textiles manufacturing, over 1,000 of them – nearly 30% – were listed as confidential and so could not be included for analysis.¹⁹² Yet increased public attention has led to a rise in transparency, as brands acknowledge that they cannot ignore the use of substances of concern in their supply chain. Brands and retailers which are transparent about and increase their accountability for the materials used to make their products can demonstrate the health of their supply chain, and reduce exposure to reputational risks. Currently, some brands are seeking individual solutions to identify substances in chemicals used throughout their supply chain. For example, VF Corp has developed CHEM IQ, a chemical management programme to test for substances of concern in the chemicals used in their supply chain, so that they can eliminate their use. Their programme manual is publicly available.¹⁹³

Aligning standards across the supply chain would also support greater transparency. Many standards exist for textiles sourcing, production, and use. While these encourage a better understanding of supply chain activities and traceability of materials, standards could be simplified and aligned to support increased adoption. To make significant progress towards the phase-out of substances of concern, the industry would need to look at improving

process inputs to the system. Examples of standards that examine the use of textile chemicals used in production include Bluesign,¹⁹⁴ which assesses all input streams, including raw materials and chemicals – minimising risks for workers, users, and the environment. Another such initiative is Oeko-Tex Eco Passport – a mechanism by which chemical manufacturers and suppliers can demonstrate that their products meet specific standards, as these are screened against their MRSL and RSL, as well as REACH and ZDHC guidelines.¹⁹⁵ Certifications can support increased transparency, for example, GreenScreen and Cradle to Cradle certifications require assessment and full disclosure of the materials used in a product.¹⁹⁶

Emerging tracking and tracing technologies hold promise for increased supply chain transparency by making data openly accessible (see Section 3.2.3.). Such systems would allow customers to access information about some of their garments, for example on their phones;¹⁹⁷ ultimately, this could become expected for all garments.

Explore the enabling role of policy

To support the shift to a new system, policy plays an important role in creating the enabling conditions for industry-led initiatives. Policy could perpetuate the adoption of best practice beyond the first movers throughout the industry, use public procurement policies to drive demand, and step in where industry practices fall short. Policies at global or multinational level could avoid inefficiencies caused by differing regional policies. Individual country actions to protect citizens, such as bans on certain chemical uses or imports, or production practices connecting upstream design of textiles with the use phase and after-use processing, would need to be aligned to these multinational approaches.

Better understanding is needed of how policymakers can support the wider adoption of practices that phase out substances of concern. Despite existing policy efforts, substances of concern remain in large-scale use throughout the textiles industry, and policy efforts face significant challenges to harmonise across global supply chains. In a number of countries, concerns have been raised about regulatory frameworks, knowledge gaps, the range of substances or applications covered, and enforcement of legislation, in addition to the

fact that existing regulations are not necessarily aligned between different product uses or regions.¹⁹⁸

Where substances of concern are not phased out rapidly enough, policy could intervene through bans on specific substances. A focus on groups of substances with similar properties would have the potential to further speed up this process. A number of policy efforts exist to reduce the risk of exposure to certain chemicals by banning their use as well as the import of products containing them. Policy efforts could seek to employ these existing platforms and frameworks, to build clarity for the industry on all chemical regulations. For example, the EU, with its REACH regulation, already restricts the use of certain chemicals in textiles production – such as azo dyes, perfluorooctane sulfonates (PFOS), nickel, and certain brominated flame retardants.¹⁹⁹ The use of NPEs in textiles production has been restricted since 2004 and will be banned from imports as of 2020.²⁰⁰

Banning the use of specific substances through policy has been shown to drive significant innovation efforts in other industries. For example, phthalates, which are used as plasticisers (see Box D), are becoming increasingly regulated, and a study by the Centre for International Environmental Law found that stricter regulations led to a large growth in patents for alternatives.²⁰¹

Regulatory intervention to increase reporting and transparency on chemical use could help set a level playing field globally. This would rapidly increase adoption of safe chemical use and support a rise in demand for better products. For example, the European Apparel and Textile Confederation (EURATEX) states that the European industry is at a “competitive disadvantage”, because REACH authorisation requirements do not apply to non-EU producers, therefore the lack of market surveillance fails to “prevent the inflow of unsafe goods”.²⁰²

Other areas where policy could rapidly drive change include factory processes and practices. For example, enforcing strict policy for textile producers regarding effluents from processing facilities would address the discharge of hazardous chemicals into the environment while factories transition to non-hazardous alternatives. Policy could also be used to enforce health standards for workers to eliminate exposure to harmful substances.

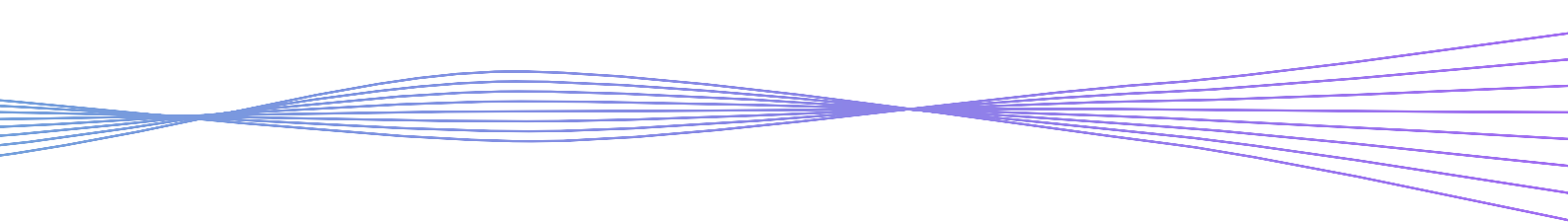
Public procurement offers another means for policymakers to drive demand for non-hazardous chemicals or process alternatives, by specifying specific criteria that suppliers must meet. For example, the EU Green Public Procurement (GPP) Criteria for Textiles Products and Services is a voluntary instrument, yet it can guide decisions on large-scale public purchasing, which could help stimulate a critical mass of demand for more goods and services, which would otherwise be difficult to get onto the market.²⁰³ Such guidelines have been piloted already. For example, in 2010, the French Ministry of Defence set procurement criteria for the supply of 150,000 cotton jerseys for its Navy. These guidelines included specifying the use of organic cotton and a list of hazardous substances – such as azo dyes and formaldehyde – that could not be used in the production process, or be present in the final product above threshold limits. This reduced the amount of substances of concern used comparative to their alternative supply of jerseys.²⁰⁴

1.1.3. DRIVE COLLECTIVE INNOVATION EFFORTS TO DEVELOP AND SCALE SAFE ALTERNATIVE CHEMICALS AND PRODUCTION PROCESSES

Rapidly shifting to safe material cycles is a key action for the transition to a new textiles economy. This can be achieved both through the development and use of safe chemical alternatives, or more innovative solutions that rethink production processes to avoid chemical use. As a first step, where safe chemical alternatives exist, these should replace substances of concern. The low transparency and complexity of the textiles supply chain will require collaboration of all actors to create a common innovation agenda, to identify and focus on priority processes where safe alternative options do not yet exist.

Scale up the use of safe alternative chemicals

Promising actions in the industry are demonstrating that it is already possible to create cost-competitive clothing while avoiding the use of chemicals that pose concern to health or the environment. Chemical producers have started innovating to bring to the market



substances required in textiles production that do not contain any restricted chemicals, while brands and manufacturers alike are partnering with them to test new products.²⁰⁵ For example, chemical company Archroma has developed ‘Earthcolours’, a palette of dyes made from agricultural waste, and which are water- and energy-saving, iron- and formaldehyde-free, and can replace conventional oil-based dyes for cellulose-based fibres.²⁰⁶ Chemical manufacturer DyStar has produced a range of dyes that have Cradle to Cradle Gold certification, and have been used in a large-scale pilot with clothing retailer C&A (see Case Study A). Beyond Surface Technologies seeks to “either fully or significantly replace synthetic crude oil based raw materials with renewable ones” and has developed a durable water repellent that does not use PFCs.²⁰⁷ Algae-based dyes may offer an alternative to traditional textile dyes as demonstrated, for example, in the EU Life project Seacolours and by designers Blond & Bieber.²⁰⁸

Further demonstration projects are needed to showcase successful use of these alternatives and create momentum to scale up the use of these better chemicals. Innovation is also needed to create process chemicals, including dyes, that are not hazardous from the start, yet which meet functional specifications.

In collaboration with textile mills, garment factories, and brands, chemical manufacturers have a significant opportunity to capture market share by developing alternative chemicals that meet both the health and environmental specifications of brands, as well as the functional specifications. Matching suppliers to brands seeking better process chemicals would support faster adoption of their use and result in an overall reduction in the costs of bringing these safer chemicals to the mass market. Tools are emerging to help facilitate this process and open up information to those smaller players that do not have the financial resources for certifications. Examples include the Chemsec Marketplace, which can be accessed for free, helps textile producers search for safe chemical substitutions, and matches them with relevant suppliers.²⁰⁹ Similarly, the ZDHC Chemical Gateway provides information on how particular chemicals in the marketplace conform with the ZDHC MRSL.²¹⁰

CASE STUDY A: C&A CRADLE TO CRADLE GOLD CERTIFIED T-SHIRTS

In June 2017, European fashion retailer C&A introduced the world's first Gold level Cradle to Cradle (C2C) Certified fashion garments.²¹¹ To achieve this level of certification, C&A collaborated with Fashion for Good, a global partnership launched with an initial grant by founding partner C&A Foundation. Two Indian-based garment manufacturers, Cotton Blossom and Pratibha Syntex, joined the project and produced the garments, as a collection of two styles of ladies' T-shirts.²¹²

Cradle to Cradle Certified is an independent, third-party verified certification programme that assesses products and materials for safety to human and environmental health, design for future use cycles, and manufacturing methods.²¹³ The C&A T-shirts achieved C2C Gold level – the second highest level – overall, and also met the highest Platinum requirements for material health, renewable energy, and water stewardship. The Platinum material health level means that no substances of concern are present in these products or used in the final stages of production, including the dyeing process. In addition, the cotton used is certified organic, so no synthetic pesticides or fertilisers are used during cotton growing.

The T-shirts are available in 18 different colours and offered in Europe at prices of EUR 7 and EUR 9 (USD 8.3 and USD 10.7). The shirts are made from pure organic cotton, including labels and threads, which supports easier recycling, with no need to separate out different materials.²¹⁴ The use of renewable energy, and the reuse of water in the factories further reduces the overall environmental impact of production.

During the development process, C&A had to find dyes that would meet the C2C Certified material health standards. To achieve this, the company worked together with dye manufacturer Dystar to develop a colour palette of over 100 different shades from eight primary C2C Certified dyes that were already available on the market.²¹⁵

When the T-shirt can no longer be worn, and no easy recycling options exist, it can be composted in home-composting units and will decompose in less than 12 weeks. At the moment, the T-shirts are not suitable for municipal composting or community organic waste bins due to acceptance criteria.²¹⁶

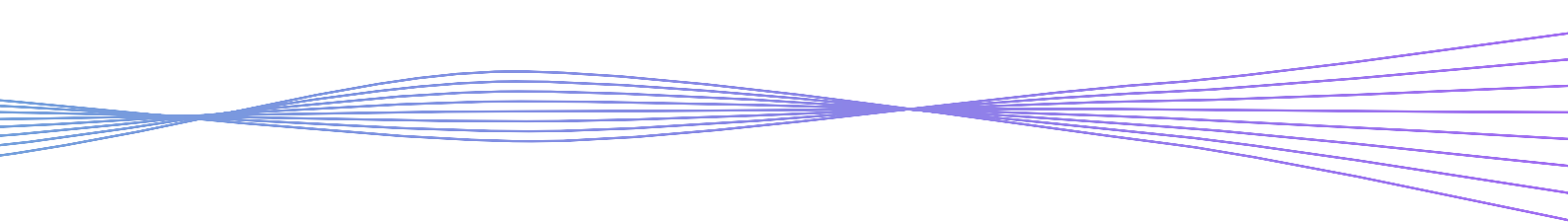
C&A sees the launch of the first Gold level C2C Certified T-shirts as a first step and intends to offer more C2C Certified products in their future collections.

Develop processes and materials that avoid using substances of concern

Collaboration between innovators, fibre producers, chemical suppliers, textile mills, and brands is needed to drive faster solutions to avoid the use of substances of concern. This could include developing alternatives to replace substances of concern as well as innovative processes that dramatically reduce or avoid the use of harmful chemicals.

Screening of existing chemical catalogues to eliminate priority substances and to create guidelines could identify areas where innovation is needed to provide the same functionality, yet without the use of substances of concern. An example is the treatment of textiles to make them 'non-iron' or crease-resistant. To

deliver this functionality, formaldehyde is often applied, a substance that is classified as carcinogenic to humans by the International Agency for Research on Cancer and linked to allergic contact dermatitis.²¹⁷ Materials and chemicals innovation could seek a solution for crease-resistance without the use of formaldehyde and other substances of concern. However, care must be taken to avoid 'regrettable substitutions' that do not consider other potential negative impacts.²¹⁸ For example, an alternative being developed in response to banned chemicals used as durable water repellents uses palm oil as a replacement, leading to new challenges for the environment related to deforestation for palm oil production.²¹⁹



Innovation in textile production processes should aim to provide desired properties for textiles, without using substances of concern. Promising innovations are emerging to reduce the negative impacts of traditional 'wet processing'. Waterless dyeing solutions and chemical-free technologies would eliminate toxic wastewater discharge during the dyeing process. Existing examples of innovation in dyeing technologies range from 90% lower water consumption (such as AirDye for plastic-based material and ColorZen for cotton) to entirely waterless solutions, free from substances of concern (such as DyeCoo for synthetic material).²²⁰

1.1.4. MOVE TO REGENERATIVE AGRICULTURE

A significant opportunity exists to transition to the use of regenerative methods in agriculture. These methods can include, for example, organic farming, no-till, and restorative grazing.²²¹ To generate maximum soil regeneration, and therefore land productivity and farm profitability, several of these methods are often combined. A regenerative agricultural system preserves the integrity of a farm's natural ecosystem, increasing its health, biodiversity, and resilience.²²² In particular, no toxic substances are used, nutrient losses are minimised, and soil health is not only preserved but enhanced. Regenerative farming avoids the negative health impacts associated with pesticide and fertiliser use, such as groundwater pollution and pesticide poisoning – the effects of which can include headaches, vomiting, lack of coordination, difficulty breathing, loss of consciousness, seizures, and death.²²³ Since the cost of pesticides can represent a huge share of total production costs – as much as 60% for small-scale cotton farmers in Africa²²⁴ – regenerative methods could also present a significant opportunity for farmers to reduce costs, and increase their control over them since inputs such as fertiliser are generated by the

farm itself. Other benefits include greater yield stability, higher quality crops, reduced water usage, and increased carbon sequestration in the soil.²²⁵

Progress is already being made towards improved cotton production, but uptake of fully regenerative methods is low. Certified organic cotton, which bans inputs of synthetic fertilisers and pesticides, represents less than 1% of the global cotton market,²²⁶ while Better Cotton Initiative (BCI) cotton, which reduces these inputs, accounts for roughly 12%.²²⁷ Long-term relationships and collaboration with suppliers could help many farmers who do not have the resources needed to make the shift to regenerative methods. Such a shift can take significant time and might need new capital and financing mechanisms. Indeed, CottonConnect points out that connecting farmers to buyers willing to pay a fair price for cotton is the “long-term solution to address poverty and create resilient rural communities”.²²⁸

Initiatives such as BCI and Cotton Made in Africa (CmiA) promote and share agricultural practices that reduce the use of pesticides, preserve soil health, and improve the health of farmers. These practices yield significant reductions in the negative environmental and societal impacts of conventional cotton farming.²²⁹ One trial in Pakistan found that these practices reduced the use of pesticides by approximately 32%.²³⁰ Instead of a third-party certification that farmers pay for, brands take the cost by paying a membership fee, making it more economically accessible to small farmers.²³¹ While of great benefit, this harm reduction approach has its limits. In a new textiles economy the expertise, networks, and financing arrangements of these or other initiatives could be extended and enhanced to stimulate the transition to a fully regenerative agricultural system to grow the crops used to manufacture textiles.

1.2. Drastically reduce plastic microfibre release

Each year, trillions of microfibres are released into the environment due to the washing of textiles, with most of them ultimately ending up in the ocean. The presence of plastics in the environment is a growing concern due to their negative impacts on ecosystems and human health. In recent years, plastic microfibres from the washing of plastic-based textiles, such as polyester, acrylic, and nylon, have been identified as a major contributor to this problem. In a circular textiles system, the release of plastic microfibres must be eliminated or its negative impacts removed.

A systemic understanding and fundamental rethink of the materials used to make textiles, and of the processes used in production, will be needed in the transition to a healthy textiles system. Two key actions have been identified to drastically reduce plastic microfibre release: develop new materials and production processes to design out microfibre shedding, and increase the effectiveness and scale of technologies that capture the microfibres which are unavoidably released.

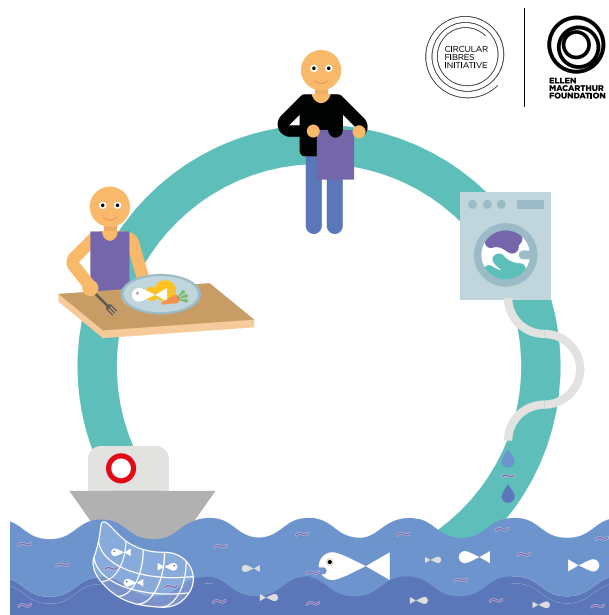
1.2.1. MICROFIBRES RELEASED FROM TEXTILES CONTRIBUTE TO THE GROWING AMOUNT OF PLASTIC POLLUTION IN THE OCEAN

The growing evidence base on microplastics highlights the numerous potential negative impacts of plastic microfibres in the ocean.

Microplastics in the ocean cause concern due to their negative environmental and health impacts

(see Box F). In recent years, microfibres have been identified as a major contributor to this problem (see Figure 10).²⁴⁷ A paper by Dr Mark Browne from the University of California brought significant attention to the issue of microfibres, reporting in 2011 on microfibres found on beaches and that the vast majority of those matched the types of material, such as polyester and acrylic, used in clothing.²⁴⁸ According to estimates, 35% of primary microplastics entering the ocean are released through the washing of textiles.²⁴⁹ The actual number of microfibres released from washing clothes is difficult to measure, and estimates vary widely sometimes by orders of magnitude, depending on the fabric and methodology used.²⁵⁰ George Leonard, Chief Scientist for The Ocean Conservancy, has estimated that there could already be 1.4 quadrillion microfibres in the ocean.²⁵¹

FIGURE 10: MICROFIBRES FROM THE WASHING OF CLOTHES ENTER THE OCEAN AND FOOD CHAIN



BOX F: MICROPLASTICS IN THE OCEAN – DEFINITIONS AND IMPACT (ADAPTED FROM IUCN)²³²

Microplastics. Microplastics are tiny pieces of plastic. The definition of their size varies in different studies, however most commonly they are defined as 5 millimetres at their largest,²³³ though some sources define the size of a microplastic as 1 millimetre or smaller.²³⁴

Primary microplastics. Microplastics in the ocean are called primary microplastics if they are directly released into the environment at microplastic size. They can either be produced deliberately, for example, scrubbing agents in toiletries and cosmetics, or originate from the abrasion of large plastic objects such as the erosion of tyres when driving or the abrasion of synthetic textiles during washing.²³⁵ Note that some sources only include the former in their definition of primary microplastics.²³⁶

Secondary microplastics. Microplastics in the ocean are called secondary microplastics if they originate in larger plastic items that are released into the environment and then degrade into smaller plastic fragments (microplastics) in the marine environment. Their main source is usually mismanaged plastic waste entering the ocean.

Microfibres. Microfibres are very short textile fibres (less than 5 millimetres long).²³⁷ Microfibres from plastic-based textiles (plastic microfibres) are a type of microplastic and are released as primary microplastics during washing.

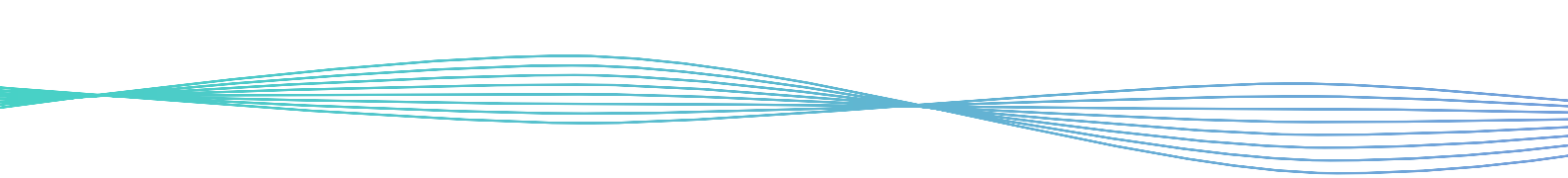
IMPACT OF MICROPLASTICS IN THE OCEAN

The contamination of marine environments with plastic is associated with various negative economic, environmental, and societal impacts.²³⁸ It has been estimated that, on the current track, there could be more plastics than fish in the ocean (by weight) by 2050.²³⁹ Plastics in the ocean are either larger pieces of plastic or microplastics. While large plastic waste and some of its associated negative impacts (e.g. through ingestion, injury, entanglement, or suffocation of wildlife) are easily visible, microplastics are largely invisible to the naked eye and the potential negative impacts are less obvious.

However, studies have shown the negative impacts of these small plastic particles, mainly due to them being digested by aquatic organisms throughout the food chain.²⁴⁰ Ingestion of microplastics has been demonstrated to cause starvation and stunted growth in some species, and to have the ability to release substances of concern by breaking down in the digestive system.²⁴¹ One study estimates that an average European shellfish consumer eats as many as 11,000 microplastic particles per year through their diet.²⁴² Microplastics additionally have the potential to accumulate substances of concern on their surface, meaning these substances can concentrate in the bodies of larger animals. Microplastics have also been found in other products consumed by humans, such as beer, honey, salt, and sugar, although the source and the contribution of textiles still needs further investigation.²⁴³

It is estimated that between 1.8 and 5 million tonnes of primary microplastics are released into the environment every year. About half, between 0.8 and 2.5 million tonnes per year, is estimated to end up in the ocean. While estimates vary, this means that between 15% and 31% of all plastics released into the ocean (from both primary and secondary sources) could come from primary microplastics.²⁴⁴

This ubiquitous contamination of the ocean by microplastics, without a clear understanding of the long-term impacts, is becoming a major concern. Given the magnitude of this global ocean contamination, some refer to the current period of human activity not as the Anthropocene, but as the Plasticene,²⁴⁵ and describe the world's ocean as a 'plastic soup'.²⁴⁶



In terms of weight, according to recent estimates, washing of textiles causes around half a million tonnes of plastic microfibrils to be released into the ocean every year.²⁵² This is equivalent to the total weight of almost 3 billion polyester tops.²⁵³ If the textiles industry continues to grow at the current rate, the accumulated weight of plastic microfibrils entering the ocean between 2015 and 2050 would exceed 22 million tonnes (see Part I, p.39).

Current wastewater treatment does not prevent microfibre release into the environment. Up to 40% of plastic microfibrils escape wastewater treatment plants,²⁵⁴ and even those that are captured often ultimately end up in the environment through leakage from landfills or sewage sludge being applied as fertiliser.²⁵⁵

Action to address the issue of microfibre release has been slow to date. Despite the growing awareness and evidence base, no changes in material choices or garment production are yet being seen at scale. Microfibre pollution presents potentially significant reputational risks for retailers. Building on the momentum of the investigation into pollution on beaches by Professor Richard Thompson at Plymouth University in 2004, and more recently by Dr Mark Browne from the University of California in 2011, research is increasingly strengthening the link between microfibre pollution and textiles.²⁵⁶

Better understanding of the sources of microfibre pollution will continue to inform the solutions to address microfibre losses and identify innovation gaps. While the case for action is clear, further research is needed to build an evidence base on the causes of microfibre pollution and the impacts of different fabric types and their production processes. Given its reliance on plastic-based fibres and a customer base that enjoys being outside in nature, the outdoor clothing industry has so far been the most motivated to respond and investigate the sources of microfibrils to seek better solutions.

Brands across the clothing industry are taking individual action. For example, outdoor clothing brand Patagonia is investing in research to increase understanding of the sources of these fibres, the consequences that they might have, and the potential solutions.²⁵⁷ Canadian retailer MEC and outdoor apparel brand Arc'teryx have

commissioned research into tracking plastic-based fibres from source to release in the ocean.²⁵⁸ Independent research is also ongoing, for example, to better understand mitigation measures at the production stage,²⁵⁹ or to develop standard tests to measure microfibre release that would enable better comparison of efforts.²⁶⁰ Given the variability in research results to date, further work is needed to build a robust evidence base that enables focused action to address the challenges of microfibre release. The Outdoor Industry Association has already begun to assemble a catalogue of the different efforts in this area, to identify the data gaps that still remain and raise awareness of the microfibre issues within the industry.²⁶¹

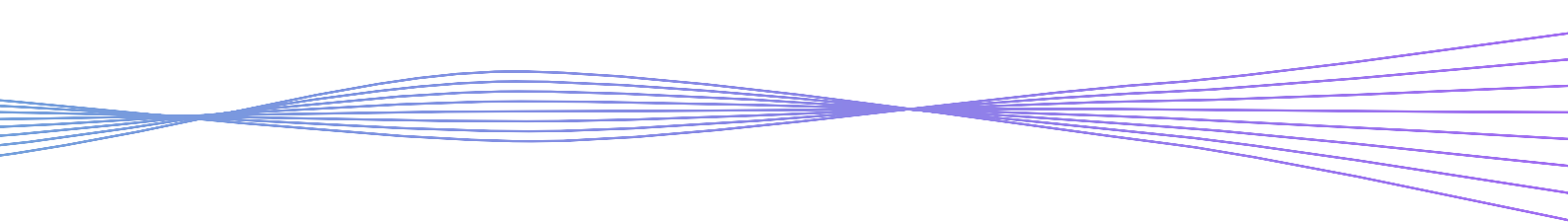
However, to rapidly address microfibre pollution, the entire industry must come together, first to identify key sources and then to create a system-level solution. The European Outdoor Group Microfibre Consortium is taking the first steps towards a concerted effort, bringing together outdoor brands and yarn manufacturers, to develop reliable and repeatable test methods for measuring microfibre release from textiles and to work towards concrete solutions. The consortium's aim is that by sharing information, a solution that benefits the entire industry can be reached more easily.²⁶²

1.2.2. DEVELOP NEW MATERIALS AND PRODUCTION PROCESSES TO DESIGN OUT MICROFIBRE SHEDDING

While the capture of microfibrils has been the focus of efforts to date, eliminating their release in the first place by changing how clothes are designed and made, is less explored. Where alternative materials with similar properties exist, this change could be achieved by avoiding plastic-based fibres. Where such direct replacements are not feasible, it could be achieved by creating new materials or adapting existing ones, or developing production processes that avoid microfibre shedding downstream.

Develop the evidence base on the causes of microfibre shedding

A study conducted by researchers at Plymouth University has determined that the quantity of fibres shed from a garment can be affected by



the washing process and fabric type.²⁶³ Building a better evidence base and understanding in the industry of the causes of microfibre release would focus actions and highlight the areas where innovation is needed to address the challenge. Research to inform the creation of a textile engineered not to shed microfibres is being conducted by innovator Biov8tion in its “Don’t feed the fish” campaign.²⁶⁴

Develop better production processes

Opportunities exist to reduce the shedding of microfibres from clothing by changing the way textiles are made. The research programme Mistra Future Fashion reports that reducing brushing (which is used to create surfaces such as fleece) or replacing traditional cutting methods with ultrasound or laser cutting could reduce the number of microfibres released.²⁶⁵ Mermaids – a European Life+ project – carried out research to understand the reasons for increased microfibre shedding and suggested that material characteristics introduced during the production processes could be responsible for greater shedding of microfibres during laundry.²⁶⁶ Material design such as fibre length, yarn spinning, weaving, and dyeing processes are all suspected to have an impact on microfibre loss.²⁶⁷ Additionally, the use of coatings has also been shown to be able to reduce microfibre losses by up to 50%.²⁶⁸

Innovate to replace microfibre-shedding materials

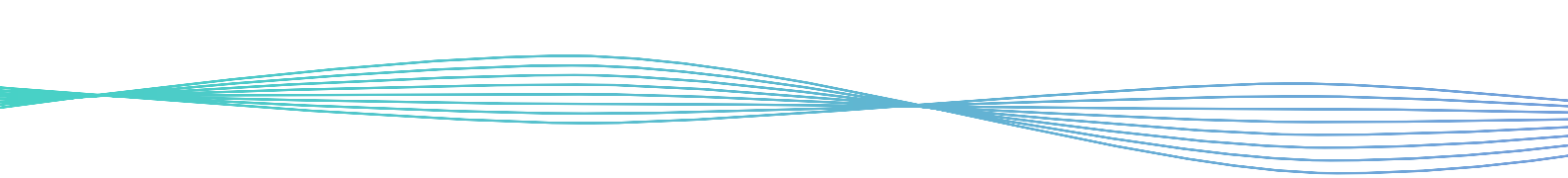
Plastic-based fibres represent 60% of the clothing market today and it is unrealistic to assume that these could all be eliminated from the material stream in the medium term, as they deliver properties which cannot currently be replicated, especially for technical and high-performance clothing.²⁶⁹ Certain products, such as fleece, have so far been the focus of studies investigating microfibres, and have been identified as releasing significant numbers of them and, therefore, may represent good candidates for innovation. In the long term, there is a need to radically rethink the materials used and to phase out those materials that cannot be prevented from losing microfibres. This will likely involve designing new materials from scratch that are either biodegradable or do not shed microfibres, and which have properties needed for high-performance applications (see Section 4.3.3 for examples of material

innovation). With increasing awareness of the microfibre pollution problem within the industry, there are many opportunities for research and development to ensure that when creating new materials, microfibre release is designed out from the start.

1.2.3. INCREASE THE EFFECTIVENESS AND ADOPTION OF TECHNOLOGIES THAT CAPTURE MICROFIBRES WHEN THEY ARE RELEASED UNAVOIDABLY

Efforts to redesign textile materials and garment production processes will ultimately be key to designing out the release of plastic microfibres into the environment. Despite this, such a transition will take time, and in the medium term existing materials will continue to shed microfibres. It is critical that effective solutions are put in place to capture those microfibres when they unavoidably leak out. Actors across the value chain have a part to play in creating a significant reduction in microfibre release overall.

Technologies exist to reduce microfibre leakage during washing, yet face adoption challenges. Entrepreneurs have responded to the microfibre challenge by creating laundry accessories (such as Guppy Friend²⁷⁰ and CoraBall²⁷¹) that contain the clothing or sit in the washing machine to capture microfibres during the wash. In addition, washing machine filters that are able to catch microfibres are available on the market, such as one developed by Wexco,²⁷² but are currently expensive and difficult to install.²⁷³ As washing machines are currently not equipped with such filters,²⁷⁴ immediate progress in this area would require the effort to retrofit millions of washing machines already in use. Incorporating filters with very small pores could also have implications on detergent use if this cannot pass through the filter, resulting in it getting blocked.²⁷⁵ Once captured, the best way of disposing of the collected microfibres also needs to be addressed, since sending them to landfill could ultimately still lead to them leaking out into the environment. To be effective at reducing microfibre release, further efforts are needed to overcome these challenges and build understanding of how to create large-scale uptake of such technologies.



Adoption of technologies to capture microfibres from wastewater is a necessary yet interim solution. Wastewater treatment plants play a critical role in the fate of microfibres in the environment, yet even the most advanced treatment systems can only capture 90% of fibres at best.²⁷⁶ However, even when microfibres are completely removed from the discharged water, they still have the potential to find their way into the environment during the disposal of sewage sludge, as this sludge is increasingly applied to land as a soil supplement.²⁷⁷ Further innovation in treatment processes and investigation of investment options are needed to scale effective capture of microfibres, which will help reduce leakage in the medium term, yet it is unlikely to solve the overall problem.

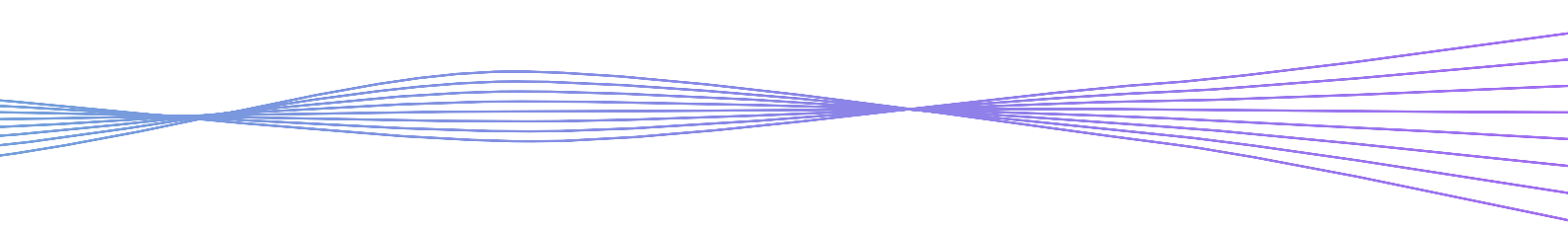
The role of policy to support the rapid adoption of technologies to reduce microfibre release should be explored. Policymakers could support the uptake of technologies related to the capture of microfibres. Regulatory efforts have not yet included the treatment of microfibres. For example, in the EU there is currently no regulation that specifically addresses the release of microfibres by textile washing processes, nor are microfibres included in the Water Framework Directive,²⁷⁸ although consultations on microplastics release, including microfibres, have started in the EU.²⁷⁹

Legislative action in the form of bans has been successful in other areas of primary microplastics. For microplastics included in cosmetic products – which are estimated to

contribute 2% of the total releases of primary microplastics in the ocean, compared to 35% for microfibres from the washing of plastic-based textiles²⁸⁰ – growing public concern and legislative action in some countries have motivated the cosmetics and body care industry to dramatically rethink their products and eliminate plastic microbeads (the small pieces of plastic used in many cleansing products such as exfoliators and toothpastes).²⁸¹ Even though the direct equivalent to this – banning all plastic-based fibres for clothing – is not realistic today, this indicates that growing attention to the microfibre issue could lead to action from policymakers.

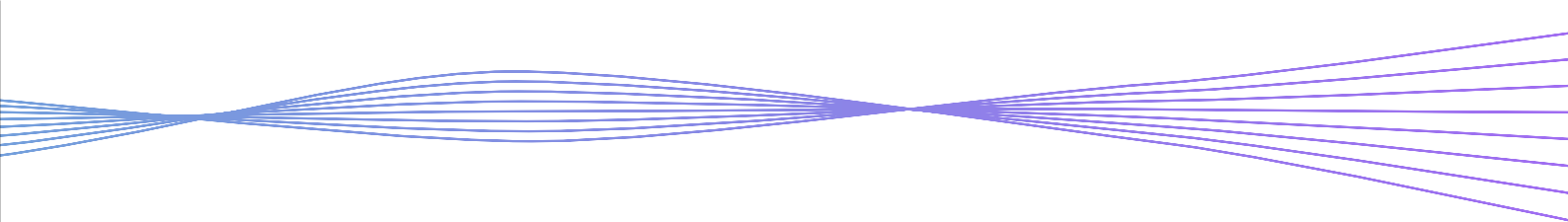
Various other stakeholders can play a part in reducing the release of plastic microfibres.

Collaborative action is needed across the whole industry to create system-level change. Research has indicated that there is a role not only for garment producers, but also for washing machine producers, detergent manufacturers, and waste management service providers to have an impact on reducing the release of microfibres into the environment. The Mermaids project highlights that washing practices and detergents affect the number of microfibres lost during a wash.²⁸² This suggests that collaborative initiatives on better labelling of care and washing instructions to promote washing practices that minimise microfibre loss could play a role.





2. Transform the way clothes are designed, sold, and used to break free from their increasingly disposable nature



2. TRANSFORM THE WAY CLOTHES ARE DESIGNED, SOLD, AND USED TO BREAK FREE FROM THEIR INCREASINGLY DISPOSABLE NATURE

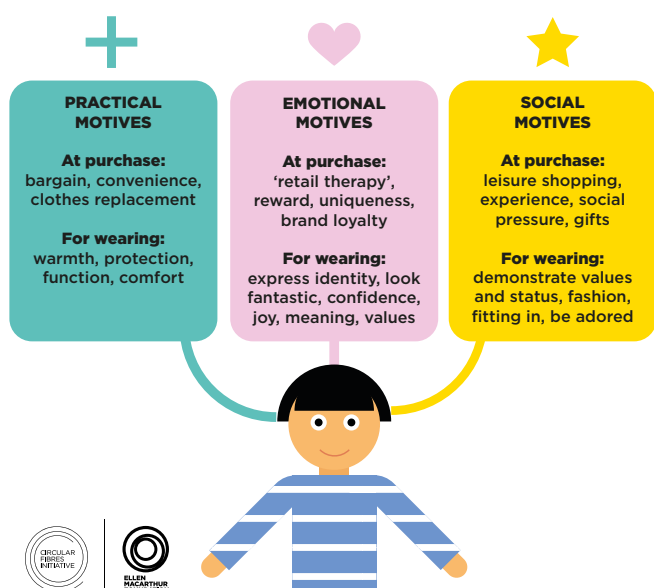
Designing and producing clothes of higher quality and providing access to them via new business models would help shift the perception of clothing from being a disposable item to being a durable product. Increasing the number of times clothes are worn could be the most powerful way to capture value, reduce pressure on resources, and decrease negative impacts. For example, if the number of times a garment is worn were doubled on average, GHG emissions would be 44% lower.²⁸³ Globally, customers miss out on up to USD 460 billion each year by throwing away clothes that they could continue to wear.²⁸⁴

To disrupt the current linear pathway for clothes, new models to access and maintain clothes are essential. Models that are not centred on ownership are needed to address fast-changing needs and styles (e.g. clothing rental). Models that explicitly offer high quality, great fit and additional services are needed to respond to segments that value durability (e.g. sales with warranties, clothing-on-demand, clothing resale, or repair services). Economic opportunities already exist for many of these models, and brands and retailers could exploit these through refocused marketing. These models would also lead to the design and manufacture of clothes that last longer, which could be further supported by industry commitments and policies. This leads to three key actions that could start the shift away from a throwaway culture for clothes: scaling up short-term clothing rental; making durability more attractive; and increasing clothing utilisation further through brand commitments and policy.

2.1. A variety of approaches is needed due to people's complex relationship with clothes

People's relationship with clothing is particularly complex. People wear and purchase clothes for a variety of motives (see Figure 11). In addition to practical motivations such as warmth, clothing fulfils more subtle emotional and societal desires, such as the expression of identity and the demonstration of values. The act of purchasing clothes can also be an experience in itself (sometimes called 'retail therapy'²⁸⁵). It is essential to recognise clothing's role as a satisfier of human needs in a societal context to ensure that this role can be enhanced by a new textiles economy.

FIGURE 11: THE RELATIONSHIP BETWEEN PEOPLE AND CLOTHING IS COMPLEX AND INFLUENCED BY A NUMBER OF MOTIVES



Source: Non-exhaustive collection of motives, based on a variety of sources, for example, Fletcher, K., *Sustainable fashion and textiles: Design journeys*, second edition (2014); Shaw, D. and Koumbis, D., *Fashion buying: From trend forecasting to shop floor* (2013); Greenpeace, *After the binge, the hangover: Insights into the minds of clothing consumers* (2017); and Armstrong, C.M., *A use-oriented clothing economy? Preliminary affirmation for sustainable clothing consumption alternatives* (2016)

In the current system – a linear economy based on traditional sales – this complex web of motives is mostly answered by selling new clothes. The current system is leading to ever lower clothing utilisation rates (see Box G) and there is evidence that excessive shopping is becoming a concern for many people in certain regions, as it is failing to meet their needs and desires.²⁸⁶

In a new textiles economy, a diversity of sales and service models for different types of clothing would satisfy customers' needs and wants while ensuring high utilisation rates. There is no one-size-fits-all solution to accessing clothes in a new textiles economy. Instead, a range of options would be on offer to match the various customer types (see Figure 12), alongside an increased emphasis on the durability of clothes from the outset. The desire for novelty and variety would be met by a vibrant rental market and an appealing resale market, offering flexibility and choice for users and new opportunities for businesses. The need for long-lasting garments would be met by offering quality guarantees and repair services for new purchases. A single individual might belong to various customer types simultaneously, and choose a different model depending on the nature of clothes sought and the specific situation. Figure 13 illustrates how the combination of various sales and service models could satisfy all typical customers' traits and types. When implementing such models, an overall strategy aimed at high utilisation rates would be needed, reflected across product design, business models, and marketing.²⁸⁷

More research is needed to support the successful implementation of new models.

Since different clothing segments and customer types have distinct needs, and there are regional differences, a variety of approaches have the potential to increase clothing utilisation. In some cases, for example, quality labelling in sales models could be successful, while in others, new business models could be the answer. While for some of the models discussed in this chapter the business case is imminent, a better understanding of which models work best for which customer types and clothing segments is still needed. Research is also required to fully understand the size of the respective markets in different regions, so that the appropriate models can be adopted for each area.

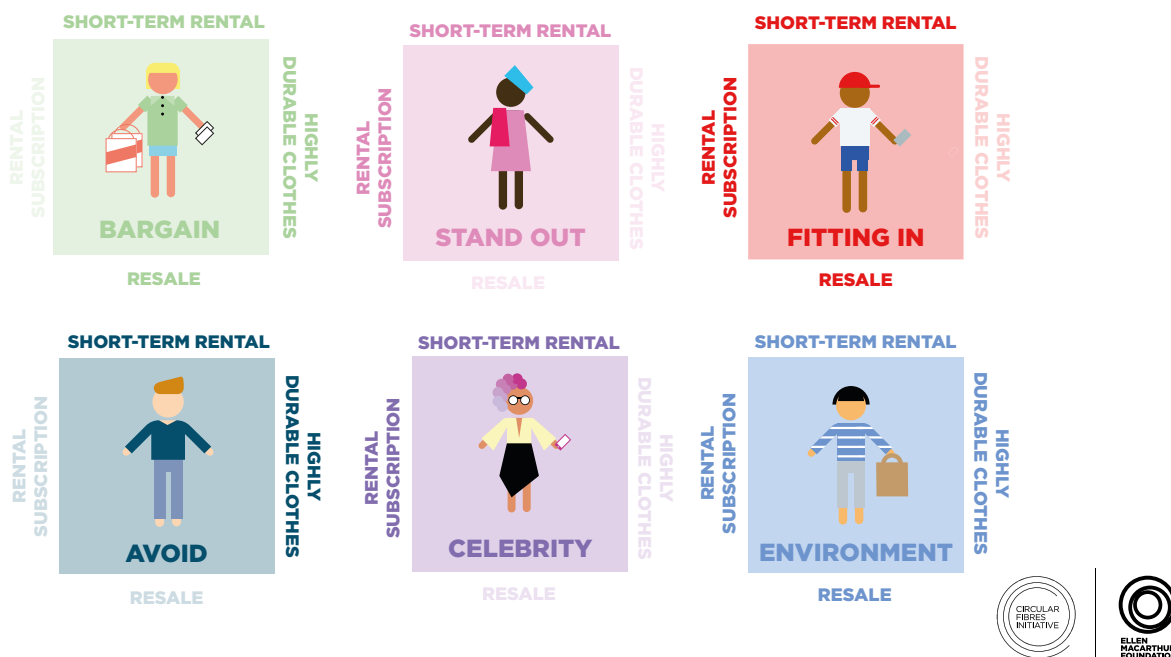
FIGURE 12: VARIOUS CUSTOMER TYPES EXIST, WITH DIFFERENT NEEDS FROM THEIR CLOTHING




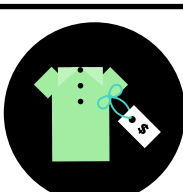


Source: Shaw, D. and Koumbis, D., *Fashion buying: From trend forecasting to shop floor* (2013), p.126



FIGURE 13: IN A NEW TEXTILES ECONOMY, A RANGE OF OPTIONS WOULD BE ON OFFER TO MATCH THE VARIOUS CUSTOMER TYPES



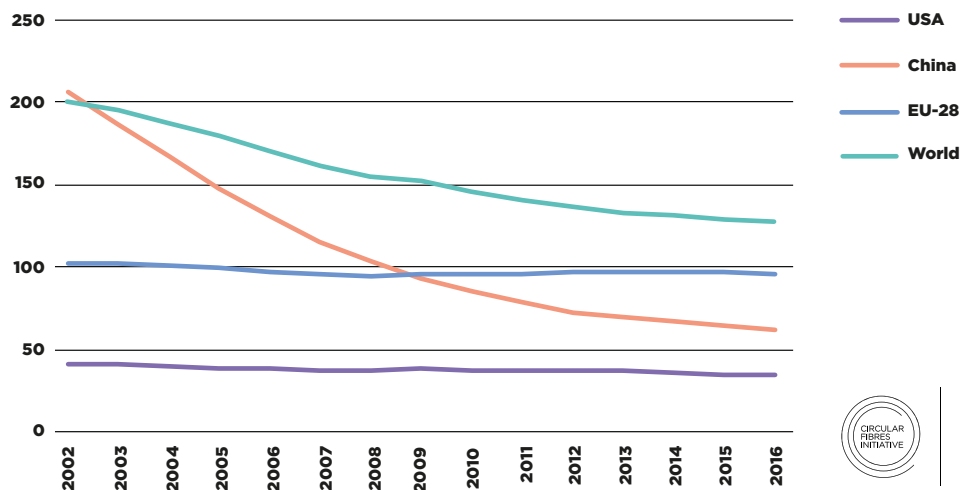
ACCESS MODEL TYPE	DESCRIPTION	EXAMPLES	CLOTHING SEGMENT
RENTAL SUBSCRIPTION 	Customers pay a monthly fee to have a fixed number of garments on loan at any one time and get frequent outfit change (see Section 2.2.1)	YCloset, Kleiderrei, Gwynnie Bee	'Fast fashion' items, all types of clothing
SHORT-TERM RENTAL 	Customers rent garments for one-off occasions and needs (see Sections 2.2.2 and 2.2.3)	Occasion wear hire, Vigga, Rent the Runway	Baby and children's clothes, maternity wear, formalwear, sportswear, luxury items
SALE OF HIGHLY DURABLE CLOTHES 	Customers specifically select high-quality, durable garments that come with a warranty, an increased personalisation, and that can be easily repaired. (see Sections 2.3.1 and 2.3.2)	Patagonia, Houdini, MUD Jeans	Staples, non-seasonal styles, workwear, intimate wear
RESALE 	Customers buy garments that have been used by others beforehand and could have been refurbished/renewed (see Section 2.3.3)	Renewal Workshop, Filippa K, ThredUp, second-hand stores	All types of clothing

1 An 'access model' is considered here as a business model for people to get access to clothes

Source: Non-exhaustive illustration based on Circular Fibres Initiative research

BOX G: CHANGE OF CLOTHING UTILISATION OVER TIME

FIGURE 14: AVERAGE NUMBER OF TIMES A NEW GARMENT IS WORN (INCLUDING REUSE WITHIN EACH REGION)



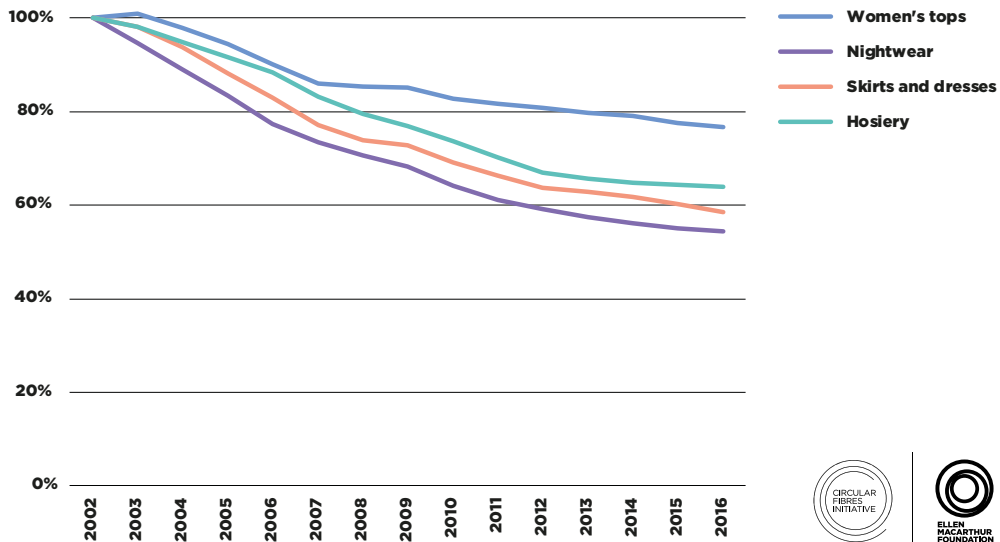
Source: Circular Fibres Initiative analysis based on Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005–2015)

THE WORLD HAS SEEN A DRAMATIC DECLINE IN CLOTHING UTILISATION IN THE PAST DECADES.

Worldwide, clothing utilisation – the number of times a garment is worn before it ceases to be used – has decreased by 36% compared to 15 years ago. This is exacerbated by utilisation rates in emerging economies tending towards the low rates of high-income countries. In China, for example, the average number has descended from over 200 wears to just 62, now lower than in Europe (see Figure 14). The transition process towards new business models of clothing provision will vary depending on region, income levels, and current clothing consumption trends. For mature markets, such as Europe and North America, the key challenge is to increase clothing utilisation rates and reverse the trend of clothing being seen as disposable. In some developing markets, where clothing utilisation is still high, the challenge is to maintain these rates as incomes rise and the middle class expands. Therefore, the business models proposed in this chapter are relevant to both mature and developing markets.

Some clothing categories are driving this trend more than others, and require greater attention. For example, utilisation of skirts and dresses has dropped twice as much compared to women’s tops, representing 3% and 4% of unit sales volumes, respectively. Utilisation of nightwear has nearly halved in the last 15 years (see Figure 15). In some categories, the trend might reflect a cultural change in style or an adoption by more people, while in others it might indicate a decrease in physical durability or a trend to use items less often. In particular, hosiery, which represents more than 20% of sales units and is less likely to be affected by style, has seen a significant utilisation decrease.

FIGURE 15: EVOLUTION OF CLOTHING UTILISATION PER SEGMENT, EXPRESSED AS A PERCENTAGE OF UTILISATION IN 2002



Source: Circular Fibres Initiative analysis based on Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005-2015)

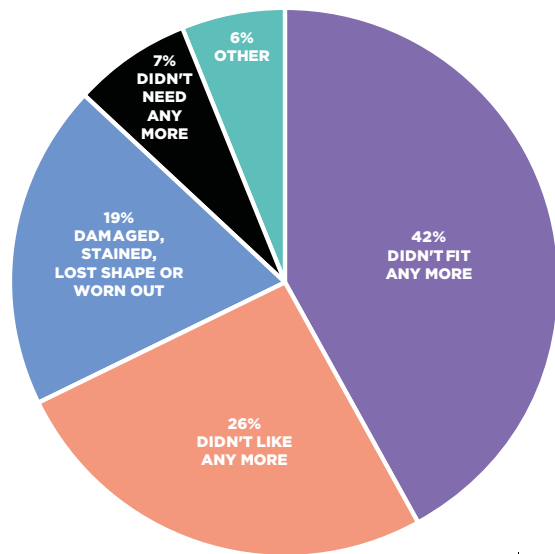
2.2. Scale up short-term clothing rental

Rental models can provide customers with access to a variety of clothes while decreasing the demand for new clothing production. Short-term rental models offer a compelling value proposition, particularly for segments where clothing users have shorter-term needs, changing practical requirements, or fast-evolving fashion preferences.

Various segments of the clothing market are suited to different rental model propositions.

UK data suggests 26% of clothing is disposed of because the owner does not like it anymore (see Figure 16), so fashion subscription rental models could meet the needs of this sector (Section 2.2.1). Additionally, 42% is disposed of because it no longer fits, opening up opportunities for short-term rental to resolve this problem (Section 2.2.2). An additional segment is characterised by the portion of people's wardrobes allocated to items only used on specific occasions, such as formalwear and sportswear – again, a rental model could be deployed here to meet these short-term needs (Section 2.2.3).

FIGURE 16: REASONS FOR DISPOSAL/ DONATION/SALE OF CLOTHING IN THE UK



Source: WRAP, SCAP textiles tracker survey (2016)



Existing businesses prove that rental models can be profitable in certain clothing segments, and that the financial opportunity could be captured more widely. However, many customers still need convincing, and existing rental models are not always financially attractive.²⁸⁹ Brands could use their vast marketing experience and capacity to make clothing rental an attractive and 'fashionable' option. Introducing rental models gives brands an incentive to design for durability, as lower rental prices and higher margins could be achieved if a product is cycled ten times, for example, rather than two or three.

2.2.1. OFFER SUBSCRIPTION MODELS FOR CUSTOMERS DESIRING FREQUENT OUTFIT CHANGES

Subscription models allow customers to pay a flat monthly service fee to have a fixed number of garments on loan at any one time. These models can provide an attractive offering for customers desiring frequent changes of outfit, as well as an appealing business case for retailers. The move to online shopping suggests there is a significant portion of customers with rapidly changing fashion demands, who put low value on the physical shopping experience itself. For these customers, short-term rental or subscription models can provide an attractive - and often more cost-effective - alternative to buying new items.

Subscription models are already disrupting the market, with brands such as Le Tote, Gwynnie Bee, Kleiderei, and YCloset. This demonstrates that there is a willingness to pay monthly subscriptions for clothing, with YCloset in China securing a USD 20 million investment to scale up in March 2017.²⁹¹ Another successful model is Rent the Runway, initially set up for online short-term rental of clothing for occasion wear and high-end luxury garments, which expanded to include a monthly rental subscription model in 2016.²⁹²

Subscription models offer several advantages for brands. Subscription services help create brand and product exposure, develop a closer and potentially long-lasting customer relationship based on loyalty, and provide a consistent revenue stream. Rental can also enable companies to gather valuable customer information directly, and to improve products and services through feedback loops. This can include product reviews, more detailed real-time information on what customers want, and potential areas of dissatisfaction such as sizing, styling, or comfort during use, as well as information about product wear and tear. This information can then feed into product manufacturing improvements to boost durability. Already, traditional retailer French Connection has partnered with subscription start-up Le Tote to access such data, leading to changes in their sizing guidelines and improved design-for-durability in some garments.²⁹³

Customers could benefit from a better experience and more variety. Subscription models offer a compelling advantage for some customers, allowing them to access the evolving trends they desire without having to buy new clothes frequently. The model also ensures that customers avoid clothes taking up wardrobe space after being worn only a few times and alleviates them of the burden of disposal after use. If clothing rental is made into a stress-free, convenient, and rewarding experience, brands could tap into the fact that experiential purchases tend to provide more positive emotions than purchases of material goods.²⁹⁴ This is in line with the general trend of the millennial generation to prefer access to, rather than ownership of, products.²⁹⁵ For example, some customers in China are becoming more selective about their spending, allocating more of their income to lifestyle services and experiences rather than products.²⁹⁶ YCloset is riding the wave of popularity for sharing

economy services in China, gaining customers in over 100 Chinese cities since their app launched in 2015. They target mid-market urban customers who want to access variety and a fresh look, but who lack the budget to buy mid-range or luxury clothing.²⁹⁷

A rapid shift towards subscription models will require further marketing efforts, making use of brands' marketing expertise and experience, and learning from sharing economy successes in other industries. Rental of clothing is not currently the norm, and not everyone might initially be open to this model. Survey data from Germany, Poland, Sweden, and the US suggests that just over 40% of customers could “imagine using fashion rental”.²⁹⁸

This suggests that some convincing might be needed to scale up subscription models. With their vast marketing experience in traditional sales models, deep expertise, and capacity, brands are in a good position to make clothing rental an attractive and ‘fashionable’ option. Lessons from existing subscription models in the fashion industry as well as sharing models in other sectors could usefully be applied. For example, subscription box businesses, such as StitchFix’s monthly clothing and styling subscription service, are becoming a trend in the US.²⁹⁹ These businesses often make use of curated services (e.g. of stylists) and aim to create a sense of identity rather than relying on functional or price benefits alone.³⁰⁰ Colin Strong from Ipsos explains how this sense of identity has worked in other sectors, such as “AirBnB and Uber, [where] rather than being seen as cheap or downmarket, using the brands signals your membership as a smart, digitally-savvy type of person”.³⁰¹ Subscription services in the US have also made use of endorsements, following a wider trend for fashion brands to use bloggers and influencers to their advantage.³⁰²

2.2.2. SCALE RENTAL MODELS FOR GARMENTS WHERE PRACTICAL NEEDS CHANGE OVER TIME

Clothing where sizes change, such as baby and children’s clothes and maternity wear, offers a natural opportunity for rental models. In these models, ownership of clothing is retained by the retailer, who redistributes clothing that no longer fits, after rigorous quality checks and cleaning procedures.

Rental models for baby clothes and maternity wear have already been successfully introduced.

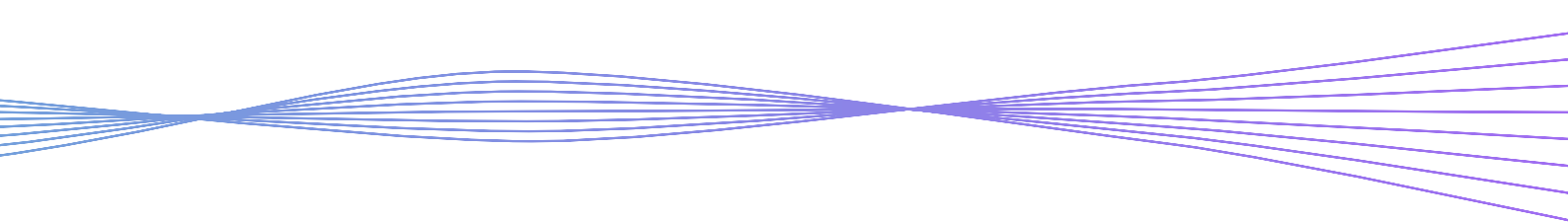
The Danish company Vigga, established in 2014, allows parents to access high-quality baby clothing for a fraction of the cost of buying new, with bundles of 20 appropriately sized baby clothing items provided at a time through a subscription service. By increasing durability, centralising washing and quality control, and streamlining operations through RFID (Radio Frequency Identification) tagging, on average Vigga circulates their baby clothes to five families before they are visibly used and go into recycling, and they are working on increasing this number.³⁰³ Similar services have emerged in other countries, for example Tale Me in Belgium.³⁰⁴ Subscription services have also been introduced for pregnant women through companies such as Borrow For Your Bump, attempting to better address a woman’s needs for maternity wear.³⁰⁵

2.2.3. SCALE RENTAL MODELS FOR GARMENTS FOR ONE-OFF OCCASIONS AND NEEDS

There are substantial opportunities in one-off rental services of clothing for special occasions, luxury, and sports. These can offer affordable access to high-quality clothes, and ensure that clothes do not take up storage space for the user when they are no longer needed. In many countries, clothing rental stores are available on the high street for special occasions, formalwear or costumes, and bringing rental services online has opened up huge growth potential in this segment.

Successful examples of these models already exist. Rent the Runway is a notable example in the US, renting more than USD 800 million in retail value of clothing in 2014 when their business model revolved exclusively around occasion wear.³⁰⁶ The Chinese luxury rental market is proving popular as well, with brands such as Ms Paris, Dora’s Dream, and One More Closet serving major Chinese cities.³⁰⁷

Houdini Sportswear has offered customers the option to rent their outdoor sports shells since 2013. This creates an attractive financial model for both the brand and the customer, who can afford high-quality performance sportswear for one weekend or week for 10–25% of its retail price, rather than buying a cheaper, low-quality



version or needing to store the garment for the rest of the year. At the same time, Houdini achieves higher overall margins by combining rental and resale. Houdini's founder, Eva Karlsson, specifies that quality is essential: "The business model absolutely works for us because the product is durable. We achieve a high resale value as the shells don't look worn after three to five weeks' rental". Sports clothing rental is also often available in tourist destinations, such as national parks and ski resorts.

2.2.4. OPTIMISE LOGISTICS FOR CLOTHING RENTAL

In a new textiles economy, reverse logistics are as critical as outbound logistics. In rental models, distribution logistics are particularly important, as products are moved about repeatedly. They need to be returned to the pool after use, in order to be checked for damage, cleaned, and re-dispatched. Considering the specific needs for clothing-rental services, six characteristics have been identified that need to be taken into account for logistics (see Box H).

As reverse logistics become a key operations challenge and opportunity, several strategies could be helpful for optimising the customer experience while preserving margins. They centre around customer segmentation, scale, and last-mile choices.

Learn from and react to customer preferences around logistics. Expectations in terms of shopping experience, convenience, and cost are different for every customer. Businesses would be well advised to develop insights in order to fine-tune logistics expenditure across their markets to maximise customer satisfaction.

Introduce new business models first in premium segments. Introducing new models first in premium segments, where margins can cover high shipping costs, would advance logistics optimisation and bring costs down, thus helping to increase scale. Rent the Runway started out with high-end and formalwear in 2009, but has since expanded into office and casual wear. Starting with high-end categories can increase brand value and build customer trust, which are useful when expanding rental and resale models into mass-market segments.

Outsource logistics services when managing scale is a challenge. Large brands and retailers might suffer from mismatched scale problems, in that – at least initially – their new business models are subscale in comparison to their regular business, and require more decentralised, small-scale distribution processes. Outsourcing can address these challenges. For example, academics have argued that national postal networks such as the United States Postal Service has a delivery infrastructure that is under-utilised and could be employed for 'first-mile' logistics.³⁰⁸ A similar argument was made a decade ago for Europe: with over 120,000 post offices and more than two million other drop-off locations such as mail rooms, as well as many state-of-the-art logistics facilities, Europe's postal services offer convenience for the individual user and an attractive bandwidth.³⁰⁹

Invest in technology to track products and materials. Easy-to-scan product coding that does not wear off with use enables both easy tracking of inventory as well as sorting of materials after use. Such systems already exist for professional textile products that are laundered centrally, such as hospital textiles or uniforms. Danish baby clothing subscription model Vigga is employing such established techniques by introducing RFID tagging and tracking to their logistics.³¹⁰ Tracking can also be facilitated through customers' online accounts, where they can mark products as being received or shipped back.

Implement customer drop-off and pick-up models. As last-mile delivery has the highest per kilometre transport costs and carbon emissions of the whole logistics chain, eliminating it could significantly reduce logistics costs. Depending on the retail model, customers could pick up and drop off their items at stores, post offices, or local self-service shipment depots. On the other hand, the trend towards same-day delivery has led to a growing number of companies investing in last-mile system developments and collaborations for their primary deliveries. McKinsey sees three models dominating in the future: autonomous ground vehicles with parcel lockers, drones, and bike couriers.³¹¹ In high-density urban settings within developed countries, these scenarios can play out in the near future, and such models could bring low-cost logistics to new business models.

BOX H: CHARACTERISTICS OF LOGISTICS FOR CLOTHING RENTAL

Logistics for clothing rental should take into account six characteristics:

Cost. It is paramount to manage the cost of required logistics – even more so because every trip is made multiple times. To save costs, clothing providers could collaborate to share distribution channels and ensure fewer, larger shipments of apparel, perhaps using click-and-collect depots that households can integrate with their existing travel, such as commutes, rather than having small, disjointed deliveries.³¹²

Quality preservation. While customers of a subscription or rental model do not typically expect to receive brand new items, there are still certain quality expectations. Hygiene and cleanliness are a minimum requirement. This means that – unlike for certain other product categories such as cars or tools – it is rather exceptional to move clothing items directly from user to user. A central or distributed care step is required, which can facilitate maintenance, quality monitoring, and retire or upgrade excessively worn items from the pool.³¹³ Importantly, the logistics need to preserve the actual and perceived quality, for example, by not causing clothing to crease, get soiled, or damaged during transport. To that purpose, subscription services often send and receive their garments in purpose-made reusable garment bags.

Information. In traditional sales models, companies rarely give much thought to the whereabouts of a garment after it has been sold, since the full (conventional) value of that garment is captured in the first – and only – sales transaction. In a rental model, it needs to be known where a garment sits at any time, when it is likely to re-enter the pool, and where it will be heading out to next. In addition, information on residual value and state of the asset (e.g. in terms of wear and tear, but also as to how fashionable it still is) is precious.

Speed. The need for speed in outbound logistics is no different from that in linear transaction schemes, where speedy delivery is an increasingly important feature in online sales. For example, US-based fashion subscription service Le Tote states that its goal is to get its unlimited-subscription members “as many totes as possible within [their] billing cycle”.³¹⁴ Rental and subscription models, however, have the additional challenge of getting products back as quickly as possible once a user does not need them anymore. This is different from conventional reverse logistics, where the primary aim is to keep cost down, because the goal is to limit a loss rather than create a revenue stream. After all, any clothing in transit is an asset that is not making money for its owner. Faster returns also allow a company to keep its inventory down. Like Le Tote, Rent the Runway uses a conventional parcel service to deliver and pick up in its “three pieces at any time” programme. They also use a local courier service for even faster logistics within Manhattan.³¹⁵

Convenience. Convenience is highly subjective but – as with speed – retailers have been steadily removing any hassle factors that might keep a customer from buying a new piece of clothing. This is true for ordering, retrieving, packing up, and sending off garments. The growing presence of conveniently located parcel lockers, and their potential integration with retail operations (e.g. the rumoured participation of Alibaba in Sposter, one of China's leading parcel-retrieval locker chains³¹⁶) could increase the delivery and pick-up convenience of online models without overly driving up costs. Online models make centralised inventory control easier, offering customers a wide selection at their fingertips. But there may also be impetus for a bricks-and-mortar presence, for example where retailers already have a store but want to add new services to their offering, something that might not be too far off, according to 2016 UK market research by Westfield.³¹⁷ This offers the benefit that customers can select and try on clothes on the spot. Rent the Runway, for example, has been expanding its physical presence in US markets, both through its own flagship stores and collaborations with other retailers.³¹⁸

Appeal. With online retailers paying increasing attention to what they call the 'unboxing experience', a lot of insights about customer experience (e.g. in terms of branded packaging) could be gathered from existing linear models and extended to the reverse logistics component. Users could be enticed to pack up clothes with care, for example by using a shipping box that, through its parallels with a suitcase, invites the customer to fold and place clothes inside rather than throw them in randomly. In a business model where parting with a product after use is an inherent element of the experience, the feeling of sending off something valuable reinforces the impression that the product was valuable to begin with.

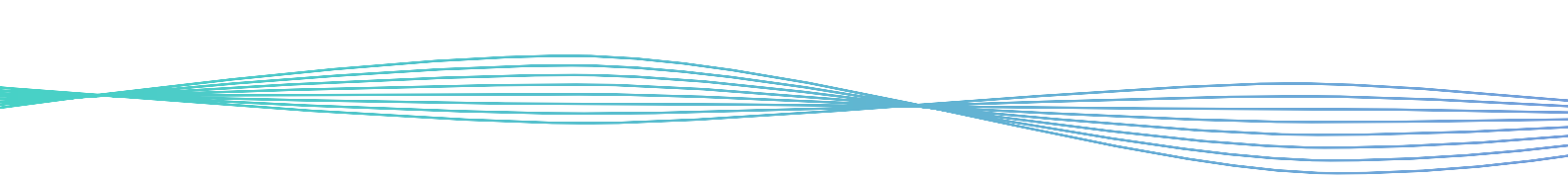
2.3. Make durability more attractive

While rental can capture the value of durability by sharing clothing between many different users, for certain clothing types and customer segments, high quality and durability can be of value even when there are only one or a few users. Many customers value high-quality, durable clothes but a lack of information often prevents them from making choices that are best suited to their needs and desires.³¹⁹ Focus on delivering quality purchases that last longer also encourages the use of new technologies that offer better fit and customisation for maximum customer satisfaction. For clothes that become unwanted but are still durable enough to be used again, enhanced resale models offer an attractive opportunity. For customers who want to retain their clothes for longer, appropriate care should be encouraged and facilitated.

2.3.1. SEIZE OPPORTUNITIES IN SEGMENTS THAT VALUE DURABILITY

For certain clothing types and customer segments there is already demand for high-quality, durable clothes. However, currently, customers often lack the information they need to judge the durability of the clothes they buy.³²⁰ Such transparency could be created through clear and aligned quality labelling or through durability guarantees. Long-term rental models, where a company maintains responsibility for the performance of a product, is another way to benefit from durability.

A clear business opportunity for more durable clothes exists in certain market segments. For segments such as wardrobe staples, non-seasonal styles, functional clothing, and intimate wear, quality is a key concern for customers. These items reflect ongoing clothing needs with styles evolving slowly over time. This segment includes coats, jumpers, jeans, socks, hosiery, and underwear, which represents 64% of garments produced globally for both women and men.³²¹ Many customers expect these items



to last and often wear them until they have a material flaw, have hard-to-remove stains, or have lost their colouration.

In some clothing categories, durability has already proven to be a key selling point.

Improving durability has broad business advantages for brands, such as reducing the risk of damaged and returned garments, enhancing competitiveness, safeguarding reputations, and increasing customer satisfaction and brand loyalty.³²² Brands like Patagonia, Eileen Fisher, and Levi's have adopted an explicit strategy around durable, high-quality clothing and have seen a strong growth in market share and profitability. Patagonia's sales revenue has seen double-digit annual growth with gross profits of USD 600 million in 2015.³²³ Newer entrants to the market such as American Giant, who has seen sales of its high-quality 'basics' and jumpers double every year since 2012,³²⁴ are pioneering a direct-to-customer model where the brand owns or closely manages their supply chain, cutting out intermediaries to offer high quality while cutting costs.

Create common quality labelling

Labelling for durability will allow customers to better judge the value of their purchases. Where durability comes at a higher production price, quality assurance is an important factor in ensuring that customers recognise the value they can capture by buying longer-lasting items.

To be trusted, such quality labelling should be consistent throughout the industry and reflect objective criteria. Developing common, ideally global, standards for labelling through agreements between brands, producers, and retailers will be key to building trust with customers. Further research is required to specify the most informative criteria for assessing durability and quality, but these could include the number of washes an item withstands or the minimum number of times an item can typically be worn without showing signs of wear and tear.

Offer warranties

Offering warranties, to repair or replace any product or component that fails, demonstrates a high commitment to durability. Several brands such as L.L. Bean, Nudie Jeans, Patagonia, and Houdini are already providing extensive warranties.³²⁵ Patagonia's 'IronClad Guarantee',

for example, offers returns, replacements, or mending if a product does not perform to satisfaction (such as a component in the design failing more quickly than expected), and repairs the product for a fee for general wear and tear damage.³²⁶ To maximise uptake of such offerings, the customer experience of returning items should be made as easy as possible, for example through free shipment and transparent guidelines.

Warranties can also offer additional advantages to brands, such as increased customer loyalty and better access to customer data. Brands offering warranties can profit from customer loyalty and longer-lasting connections with customers.³²⁷ Customers retaining contact with the brand when a product no longer matches their needs could also make it easier to get used clothing back for resale or recycling. In addition, warranties provide invaluable data to brands on what happens to their clothes post-purchase as they create a direct channel for users to give feedback regarding durability and customer satisfaction. This data can be used by brands to make improvements in design and manufacturing to further increase durability.

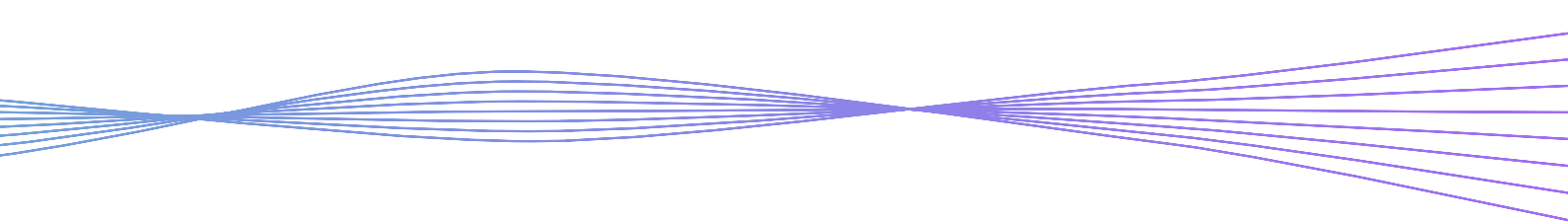
Maximise the potential of durable clothes through long-term rental

Companies can offer long-term rental and maintenance as a service, retaining ownership of the clothing. Such rental models increase the financial attractiveness of producing more durable clothes, as the manufacturer or retailer can capture more value, the longer the clothes lasts. For customers, the added value is in knowing that they are accessing a high-quality product without the associated upfront costs or risks. Long-term rental agreements also create an easy channel through which to get materials back.

Long-term rental agreements could reach scale in segments such as workwear and uniforms.

The requirements around workwear often align with durability needs, such as for protective clothing or uniforms which require frequent washing, for example in the catering industry. Business-to-business markets are particularly suitable for such long-term rental or 'clothing-as-a-service' models.

In the UK, 90% of corporate clothing is sent to landfill or incineration – an estimated 16,000 tonnes³²⁸ – even though clothing collection



systems capture around 50% of other types of clothing for reuse and recycling.³²⁹ This highlights a significant business opportunity for value capture, in particular as the users of corporate wear are far easier to reach for clothes recapture.

Major employers such as hospitals and construction firms could create demand for workwear rental models through their procurement. In addition to the ‘push’ effects of clothing producers offering long-term clothing contracts, the business case for long-term, quality rental can also come from ‘pull’ effects: major employers demanding more high-quality, circular clothing for their uniform and workwear needs. For uniforms and protective corporate wear, many mainstream providers already offer full-service packages, including long-term rental and laundry services, such as PHS Group or UniFirst, helping employers outsource their uniform management and logistics. Dutch Awearness takes this model one step further, attempting to create a closed-loop recycling service for uniforms that are provided as a performance-based service. They offer suits, high-visibility uniforms, and protective healthcare clothing through long-term rental contracts, in which they also manage collection, laundry, and closed-loop recycling processes, thus attempting to create a fully circular model.³³⁰

The opportunities for long-term rental in other segments need further research, but start-ups are already creating a proof of concept. For example, MUD Jeans has been providing a ‘Lease A Jeans’ option since 2013, for a monthly fee, with a repair service included. Customers can either keep the jeans after 12 months or return them and switch to a new pair.³³¹ They stay connected with the brand and the model encourages increased loyalty. This business model currently appeals to ‘conscious’ customers; more research is needed to reach a mainstream market.³³²

2.3.2. SCALE UP SERVICES TO PROVIDE INCREASED PERSONALISATION OF CLOTHES AT PURCHASE

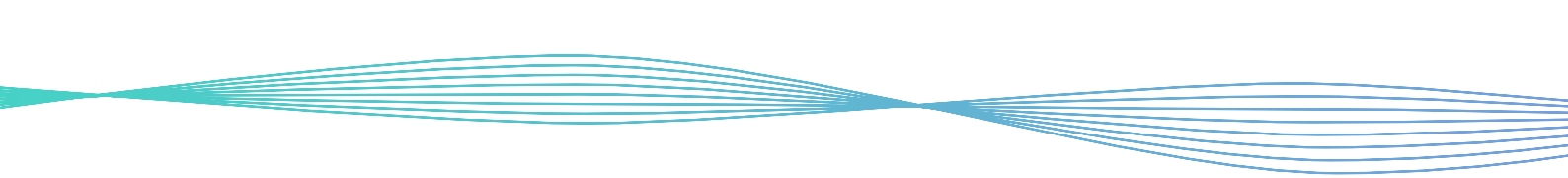
Higher durability is only of value if customers actually wear the clothes they buy. Personalisation services, such as manufacturing

customised garments on demand, providing fitting services at the point of purchase, or designing clothing that adapts to changing needs, could all be scaled up to increase clothing utilisation.

Emotional durability could be enhanced by involving the user in the making or remaking of their garment. An emotionally durable item is an item that is highly valued by its owner, for example due to its making process (e.g. tailor-made, custom-ordered, designed, or self-sewn), or its maintenance and redesign.³³³ Participation of the user in the design or repair of clothing has the potential to foster a more connected and active engagement with garments. It aligns with the idea that the quality of design increases if the person who ultimately uses the product is included in the design process.³³⁴ For example, the platform Betabrand allows anyone to submit a design idea, crowdfund it, and produce items if the idea proves popular.

New technologies are emerging that adapt clothing to individual body shapes and styles, allowing custom-made clothing to be delivered at scale. Until the 1800s, ‘made-to-measure’ clothes were the norm and are still common in certain countries, such as Ghana.³³⁵ Globally, they have been largely displaced by ‘ready-to-wear’ mass produced clothes in standard sizes. New technologies could help customisation re-enter the mainstream market. 3D body-scanning technologies are already available to provide body-mapping analysis which, along with a fitting guide, could customise the perfect garment for the customer. This means that on-demand manufacturing does not necessarily mean long delays to acquisition. For example, Fame and Partners has developed a technology platform and supply chain that allows custom-made clothing to reach customers two to five days after ordering. Women can specify their height for improved fit, choose from 20 colours, and select from a number of design options.³³⁶

Locally distributed production through the sale of designs online that can be 3D-printed locally and easily assembled by the customer is another innovation that has the potential to create products only where and when they are needed. Such a model is currently being explored by the Post-Couture Collective in Belgium.³³⁷ On-demand manufacturing could also reduce brands’ need to discount or discard overproduced items.



Designing clothes that will adapt to changing user needs is on the horizon. Clothing that is designed to be multi-purpose, adaptable, and upgradable could increase the frequency with which customers use an item, and lower the number of items they keep in their closet. There is an opportunity for designers to create modular garments that can be adapted by users over time. Garments that can be worn inside out, or that are made up of a fixed base together with removable sections that are offered in multiple colours, would allow one garment to match several outfit combinations.³³⁸ There are already examples of this kind of multifunctional design, such as the concept of the Little Navy Dress, which consists of a ‘blank canvas’ onto which customers can zip decorative attachments.³³⁹ Adaptable materials that are easily upgraded represent a new area of innovation, whether they are garments that can be re-dyed or refashioned at home, or are self-adaptive. For example, Petit Pli’s children’s clothes are pleated in such a way that they grow with the child and fit a wide range of sizes.³⁴⁰ At the more exploratory end of fashion, CuteCircuit garments include ‘wearable technology’, incorporating built-in images that are updatable through a mobile app.³⁴¹

2.3.3. MAKE RESALE ATTRACTIVE TO A WIDE RANGE OF CUSTOMERS

As the average quality and durability of clothing on the market increases, so will the opportunity of capturing its value through resale. Clothing resale is already widely adopted across the world, particularly through charity shops and online resale, but misses opportunities, in particular in regions with low rates of clothing utilisation, where around 70% of the clothes collected for reuse is sent overseas.³⁴² Provided that clothes are increasingly made to last, introducing attractive resale models suited to a wider customer base locally (i.e. in the same countries where clothes are being discarded) could significantly increase clothing utilisation. To achieve this, innovative resale models and partnerships are required, also harnessing digital technology. Some businesses are already seeing high levels of resale when focusing on quality and curation,³⁴³ and brands and retailers are well-positioned to capture parts of this growing market, which would also allow them to keep better control of their brands.

By putting customer experience first and making resale models convenient and accessible, resale could become a new norm. In addition to the economic rationale, measures could be taken to make the purchase of pre-owned clothes more attractive to customers through increased convenience. In addition, in the same way that making the quality of new clothes visible (see Section 2.3.1) could change buying habits, showcasing the quality and hygiene of renewed clothing could drive the uptake of pre-used clothing sales.

In other sectors in the past, focusing on quality and customer experience created similar shifts, for example making sleeping in hotels acceptable, where bed linen is washed and reused. Innovative and digitised models for centralised control of stock, with slick methods for customers to filter and easily find an available match, along with guaranteeing hygiene and quality, could have a significant impact on the frequency with which clothing is shared and the cost of doing so.

Digital technology has the potential to disrupt formal as well as informal markets for used clothing. Other industries have already been disrupted by the digitisation of services (e.g. financial services, audio and video services)³⁴⁴ and the clothing industry is likely to follow this trend, exemplified by the online resale market growing more than four times faster than the traditional second-hand store market (35% per year versus 8% per year).³⁴⁵ ‘Resale disruptors’ represent a specific segment of the apparel resale market, as they offer a more curated product assortment and sell their products via peer-to-peer marketplaces (i.e. bringing buyers and sellers together within a hosted platform to perform transactions), augmented marketplaces (i.e. taking on logistics, photography, and customer service to deliver a more convenient customer experience), and retail stores.³⁴⁶ Pre-used clothing can be accessed online through sales (e.g. The RealReal, ThredUp, Vestiaire Collective) and free direct exchange websites (e.g. The Freecycle Network).³⁴⁷ Such platforms and tools are convenient for connecting supply and demand, and, as well as providing adequate methods of guaranteeing quality and presenting clothing in an attractive way, could be further exploited to significantly increase the sharing of clothing across many users.

Retailers have the opportunity to take some control of their resale market and bring resale into the mainstream.

By selling used clothing alongside new clothing, fashion retailers offer an appealing and convenient option (i.e. using the usual channels for shopping). This could help reposition clothing resale from a fringe to a mainstream activity. Introducing such resale activity has the potential to be a low-risk and high-reward activity for brands, as it would create additional profits while feeding into the perception of quality, and promoting a brand's interest in increased usage of its clothing. Additionally, it could allow brands to attract new customers and, by making it clear to customers that their clothes still have value, incentivise them to bring used clothes back. This could initiate a positive spiral to accelerate the shift to greater utilisation of clothes.

Some brands that focus on quality are already successfully capturing the value of their garments' resale sector. For example, Patagonia, with their Worn Wear initiative,³⁴⁸ and Filippa K are already benefitting from setting up a platform for the sale of their pre-used clothing. They are capturing a market they would otherwise not have, while at the same

time increasing the visibility of their brand and making clothing resale a common option.³⁴⁹ Luxury brand Stella McCartney has partnered with resale company The RealReal, to encourage their customers to sell their items once they do not need them anymore.³⁵⁰

Partnering with third parties can help brands to adopt resale models more quickly and flexibly.

One of the challenges for fashion brands and retailers to rapidly implement resale activities at scale is their limited experience with best practices.³⁵¹ Partnerships with third parties could provide the know-how needed to manage activities such as logistics, renewal, and repair. Such services are already emerging. For example, The Renewal Workshop works together with brands, creating a stock of renewed clothing and sharing the revenue from sales with the brands (see Case Study B). Yerdle Recommerce also makes it easy for brands to buy back and resell used items, providing “brands with the technology and logistics to develop white-label resale channels that take back control of the secondary market, deepening customer engagement and increasing profits”.³⁵²

CASE STUDY B: THE RENEWAL WORKSHOP³⁵³

The Renewal Workshop partners with apparel brands to create value from their in-shop returned items, implementing a sales channel from high-quality, unwanted clothing. Founded in 2016, the company offers retailers a fully outsourced service, managing the reverse logistics, repair, cleaning, and resale of branded stock that customers return for any reason, whether the clothing is unused, lightly used, or in need of repair. Partnership fees for processing the clothing are comparable to what retailers would pay normally for waste management, but rather than disposing of the clothing, the renewed clothing is resold, either in-store by brands, or on The Renewal Workshop's website under a revenue-sharing agreement. Their first clients included mid-range sportswear brands Ibex and prAna.

“We are helping companies sell renewed clothing side by side in their stores. The idea is to really brand the durability story by showing how their clothing lasts and retains its value,” explains the co-founder, Nicole Bassett. The start-up also helps brands to improve durability in their product design by giving feedback on trends they see in product failures, such as button placement or seam failures.

All resold clothing is quality-certified, and renewed using a waterless washing technique to restore garments to a very clean state, reducing hygiene concerns. The aim is to remove the barriers to cycling clothing through multiple users, providing used high-quality clothing at attractive prices. Of the stock that The Renewal Workshop receives from retailers, 65% is resold, with half of the remainder used to produce other products such as pencil cases.

2.3.4. BOOST CLOTHING CARE

Easily accessible services and widespread support for users to maintain their clothes for longer (e.g. through repairing or restyling, and adequate washing and storing) could help to preserve the integrity of clothes and keep them at their highest perceived and actual value.

Large-scale adoption of clothing repair and restyle services could significantly increase clothing utilisation. In regions where the cost of new clothing is low relative to the cost of labour, repair and restyling services are often not profitable, and existing activities are mainly motivated by ethics or lifestyle choices. However, as the physical and emotional durability of garments increases, the demand for and economics of those services could increase as well. This could also open up opportunities to introduce novel clothing services, such as garment restyling or consulting, to advise on upgrades, customisation, and mending at home. Retailers could also provide repair and other services in-store, for example, in collaboration with third parties, or form partnerships with repair and restyle providers based in local communities.³⁵⁴

Several brands already offer in-store repair and incentivise users to keep their garments well maintained, in particular, outdoor clothing brands such as Bergans, Jack Wolfskin, Patagonia, Salewa, and Houdini, which offer repair services for their used products.³⁵⁵ Patagonia, for example, operates the largest (and still growing) repair facility in North America, repairing about 50,000 pieces per year.³⁵⁶

Clear labels and guides could increase utilisation by making it easier for users to care for their clothes. Labels could be introduced more widely, providing maintenance information, such as repair instructions or washing and storing tips to reduce wear and tear. These could also reduce water and energy use, for example by encouraging washing at lower temperatures and avoiding tumble dryers.³⁵⁷ Smart labelling solutions (e.g. Near Field Communication (NFC) tags) could provide that information without overloading the garment with physical labels.³⁵⁸ For example, each garment from Khongboon Activewear contains a microchip located behind the brand's logo that can be tapped with a phone to provide the latest information.³⁵⁹ Free, easy-to-follow repair guides could also be made available online to support customers'

mending activities, as introduced by Patagonia and their collaboration with iFixit. This would simultaneously enable more quality used clothes to be kept for resale.³⁶⁰ Labels and guides could also include end-of-use information about disposal of clothing in appropriate channels.

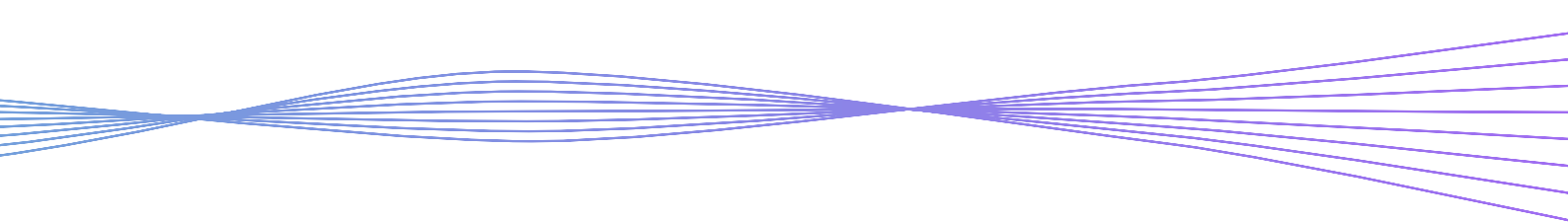
2.4. Increase clothing utilisation further through brand commitments and policy

While some market segments, as described above, have a compelling business case for durability, reversing the recent trend towards low quality and low usage rates in today's clothing market might require additional support. Driving high usage rates requires a commitment to designing garments that last, an industry transition which can be advanced through common guidelines, aligned efforts, and increased transparency. Policymakers could also play a role in further increasing clothing utilisation.

2.4.1. BUILD INDUSTRY COMMITMENTS TO INCREASE DURABILITY

Commitments by brands and retailers to sell more durable garments could create momentum and should be welcomed at a time when brands are increasingly held accountable for the impact of their clothes. Indeed, low-quality clothing is leading to heightened scrutiny from some citizens and the media, with accusations of 'designed obsolescence' being used as a tactic by brands.³⁶¹ In addition to making quality visible and offering guarantees and warranties where there is demand for it (see Section 2.3.1), quantitative targets in collective commitments could help move from concern to action.

Tools and strategies to make clothes last longer are increasingly being brought into focus. Ways of increasing durability could include using durable materials, strong seams, and lasting dyes and prints that can withstand multiple use cycles. Enhanced knowledge, transparency, and accountability must be built



in throughout the supply chain to ensure that better quality can be pursued as a goal. This will enable a shift in focus throughout the processes of design, sourcing, and construction to create garments that last and can easily be repaired.

Already, major brands have created supply-chain mechanisms to ensure fair labour rights and non-toxic products, and such communication and transparency efforts could be expanded to focus on the quality of production. Existing frameworks and tools offer guidelines on how brands can adopt a focus on durability, such as the Higg Index and its Design and Development Module,³⁶² the Waste & Resource Action Programme's (WRAP) Clothing Longevity Protocol,³⁶³ or the recent Design for Longevity platform from the Danish Fashion Institute for the European Clothing Action Plan,³⁶⁴ but these practices should move further in the implementation phase across industry players. An industry-led, adequate minimum-quality assurance could be developed with agreed specifications, laying the groundwork for how regulators could monitor and support the transition of fashion away from disposability in the future. Specifications would apply to sourcing materials, yarn, and fabrics, asking the right questions of suppliers, testing garment durability in the washing and use phase, setting goals around how long clothing lasts and is used, and communicating transparently with customers.

Significant improvements in durability are possible at minimal extra cost. Although cheaper production is sometimes achieved by cutting quality, there are also significant opportunities to increase durability that are cost-neutral, profitable, or that have clear financial benefits due to enhanced brand reputation. Practical guidelines for the design phase of garments are available, such as those released by WRAP as part of the Sustainable Clothing Action Plan,³⁶⁵ but concrete goals and targets around durability are required to move to the implementation phase and achieve scale.

2.4.2. EXPLORE THE ENABLING ROLE OF POLICY

Policy could help accelerate the shift towards higher clothing utilisation, by setting the right conditions for business models in which high usage rates can flourish, and by imposing some mandatory actions to move the whole industry away from low utilisation trends. Once the

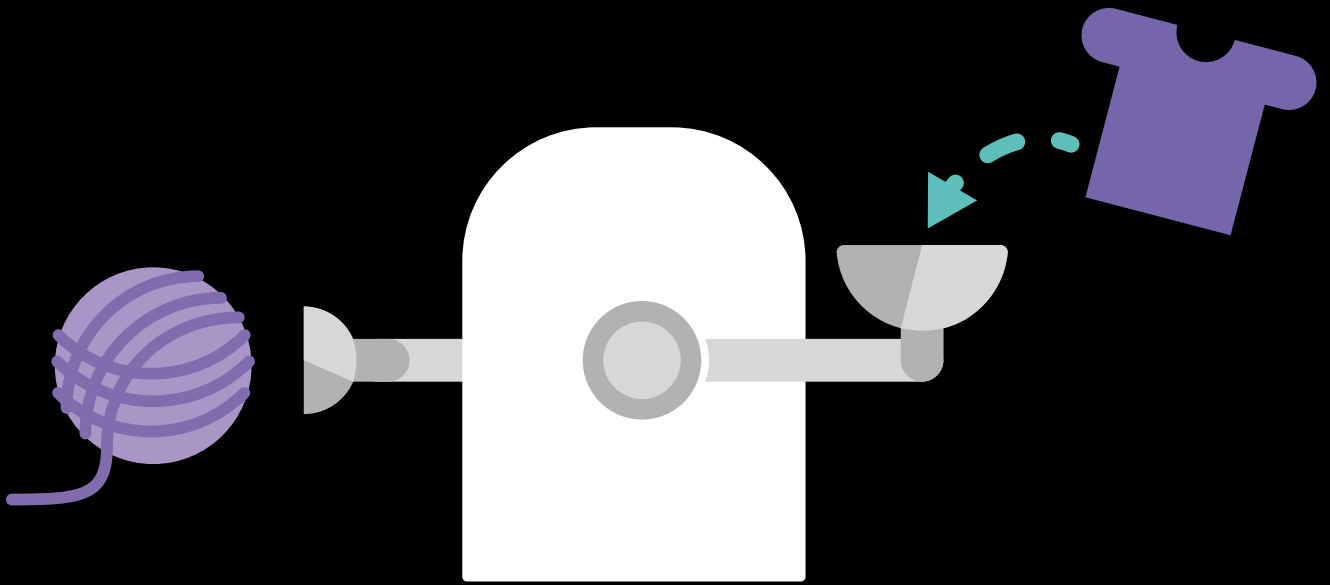
industry has shown, through commitment, that durability standards, warranty systems, and financial incentives for certain types of business models can be successful, policy could ensure their full implementation by making them mandatory.

Introducing Extended Producer Responsibility (EPR) focused on textiles could be considered an enabler for increased utilisation and as a financial incentive for resale models, rental models, and high-quality clothing. EPR has been successfully pioneered in France since 2007 for clothing and will be extended for home textiles in 2020. Companies are obliged to either set up a recycling and waste management system for the clothes they put on the market, or pay a contribution to an organisation that will financially support third parties to manage clothing waste.³⁶⁶ Although this EPR focuses on recycling, overall reuse rates increased as a result of increased collection rates, and additional policy measures could keep clothes at a higher value by ensuring the sorting of collected materials according to quality specifications.³⁶⁷ A mandatory EPR programme could be a financial incentive for brands to set up their own take-back and repurposing system, whether through rental or resale. It could also bring more third parties into play to handle collection, refurbishment, and redistribution at scale.

The scope of an EPR scheme could also include actions to increase quality and durability further. Once EPR is in place, third parties could provide financial incentives to their members who design and make clothes with high quality standards. For example, the waste management coordinator Eco TLC in France offers a 50% discount on the eco-contribution fee relative to EPR for members who use at least 15% recycled fibres as input in their products.³⁶⁸

Other policy options could be explored to stimulate clothing resale and repair. For example, services could profit from reduced tax rates. Such policies are already starting to be implemented; for example, since 2017, in Sweden, VAT rates are 50% lower for repair services of items like clothes, shoes, and bicycles.³⁶⁹

More research is needed to explore the role of policy in setting the right conditions for the adoption of high clothing usage rates; nevertheless there are key opportunities for policy to aid a systemic shift.



3. Radically
improve recycling
by transforming
clothing design,
collection, and
reprocessing

3. RADICALLY IMPROVE RECYCLING BY TRANSFORMING CLOTHING DESIGN, COLLECTION, AND REPROCESSING

Radically improving recycling would allow the industry to capture the material value of clothes that can no longer be used. Currently, less than 1% of textiles produced for clothing is recycled into new clothes, representing a lost opportunity of more than USD 100 billion annually and high costs for landfilling and incineration. This is a significant opportunity, even if the industry could only capture part of it. Using recycled rather than virgin materials also offers an opportunity to drastically reduce non-renewable resource inputs and the negative impacts of the industry.

Coordinated action is required to capture the opportunity to introduce clothing recycling at scale, involving designers, buyers, textile collectors (including cities and municipalities), recyclers, as well as innovators. Four areas of action – if coordinated well across the value chain – could start the process of capturing that value: aligning clothing design and recycling processes; pursuing technological innovation to improve the economics and quality of recycling; stimulating demand for recycled materials; and implementing clothing collection at scale.

3.1. Cross-value chain action is required to introduce clothing recycling at scale

Worldwide, no clothing-to-clothing recycling³⁷⁰ operations exist at scale. While textile recycling has been in operation for at least 250 years,³⁷¹ recycling technologies still have significant limitations. For example, mechanical recycling processes shred materials to recapture the fibres, which often results in inferior quality in comparison to virgin materials. While chemical recycling technologies can return fibres to virgin quality, they are not yet technologically or economically mature.

Currently, 87% of material used for clothing production is landfilled or incinerated after its final use, representing a lost opportunity of more than USD 100 billion annually, coupled with negative environmental impacts.³⁷²

This is true for offcuts that occur during textiles production as well as used clothes. Addressing the latter problem is made harder by a lack of large-scale systems to collect and sort used clothes. Even when such systems do exist, value is still often lost. For example, in Sweden, a country where textiles are collected separately at high rates, there is little recycling of non-reusable textiles: they are routinely incinerated.³⁷³ Globally, most used textiles end up in landfill. Such poor waste management leads to a loss of the value in the material and takes up landfill space, which costs money and is scarce in many countries. Once discarded in this way, clothing still causes negative environmental impacts. As they decompose, natural fibres such as cotton and wool generate the greenhouse gas methane, which is released into the environment if the landfill is not properly controlled.³⁷⁴ Plastic-based fibres will remain in landfills for decades, with the average polyester product likely to survive for over 200 years.³⁷⁵ Additionally, substances of concern that were applied during production processes, for

example to colour or treat the item for specific properties such as water repellence, can be retained in the clothing and then escape into the environment if not correctly controlled (see Section 1.1.1).

Most of the material being recycled is cascaded to lower-value applications. Common purposes for recycled textiles include cleaning cloths, insulation material, and mattress stuffing. These applications are typically not (economically) recyclable after use, so this generally adds just one additional use before materials are discarded.³⁷⁶

Recycling textiles into cascaded applications usually requires minimal processing. To create cleaning cloths – used for cleaning and polishing in various industries, for example print or heavy oil – after the removal of metal and plastic parts, textiles are sorted and cut into various sizes.³⁷⁷ To create filling and insulation materials – for example for mattresses, furniture, or insulation for buildings or vehicles – textiles are simply shredded.³⁷⁸

Where recycled input is used to make clothing, this is often downcycled from other industries.

Around 2% of input for clothing production comes from recycled materials, mostly polyester from recycled PET bottles.³⁷⁹ While this forms an important contribution to the reduction of virgin input to the textiles industry and an important proof of concept for the use of recycled materials in clothing, there is a risk that in the long run this prevents higher-value recycling in those industries and suppresses clothing-to-clothing recycling. Yarn manufacturers, such as Polygenta, Polyterra, Hilaturas Ferre (with their brand Recover), and Unifi (with their brand Repreve), produce recycled polyester yarn from PET bottles.³⁸⁰ This is then used in products by brands such as Adidas, C&A, H&M, Nike, and many others.³⁸¹

Clothing-to-clothing recycling at scale is hindered by a disconnect between design and recycling processes. The way clothing is made, including the way fabric is constructed and chosen for clothing, rarely considers the recyclability of the materials once they are no longer used. Specifically, the ever-increasing number of materials and blends brought to the market makes it hard for recyclers to capture the full material value of clothes they receive (see Box I). To put this in perspective, the Higg Index – a self-assessment tool developed by

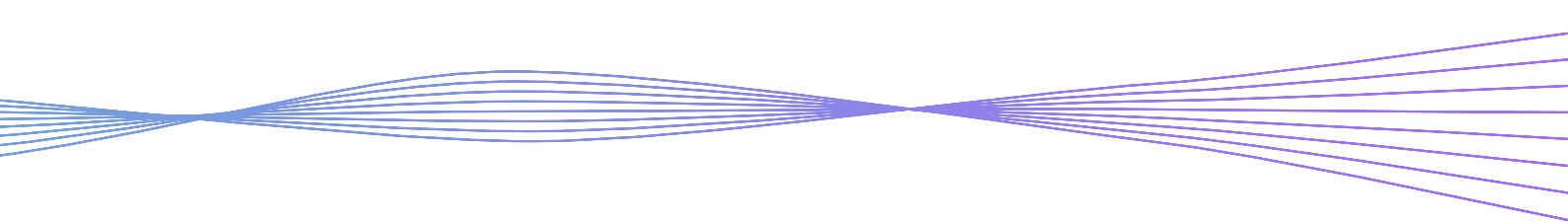
the Sustainable Apparel Coalition³⁸² – lists 78 base materials that can be produced using 241 different processes to create more than 165,000 possible material combinations.³⁸³

Coordinated and compounding action is needed to overcome these drawbacks and capture the opportunity to introduce clothing recycling at scale. This includes connecting designers and buyers with recyclers and the producers of recycled materials, to better understand the materials available to them and the impact of their design and material choices on the recyclability of a garment. Also, textile collectors, sorters, and recyclers need to work with brands and retailers to considerably scale up the collection of materials for recycling. Involving innovators could steer materials innovation in the direction needed by the industry to support a new textiles economy. Research is needed to understand material flows from other industries into apparel, as well as outflows from apparel into other industries, to understand the value of cross-industry cycles.

3.2. Align clothing design and recycling processes

Converging towards an optimised palette of materials – including blends where these are needed for functionality – and developing these alongside highly efficient recycling processes for those materials is a crucial step in scaling up recycling. This also includes developing new materials where no current ones are suitable to provide both the desired functionality as well as recyclability. Universal tracking and tracing technologies – integrated in the design of clothing and aligned to processes across the value chain – will be needed to support the identification of materials in the system to improve the output quality of the recycling process.

Transparency on the materials flowing through the system is key to improving recycling rates. Recycling technologies rely on accurate materials detection and sorting to ensure well-defined material streams (either a single material or well-defined combinations of materials including blends). Correct labelling



and materials identification is therefore paramount to accurately sorting collected clothing for recycling, yet currently information given on labels does not always provide the full picture. For example, the US Federal Trade Commission clarifies that a product can be labelled 100% cotton even if it contains non-cotton trims.³⁸⁴ Incorrect identification of materials can disrupt the recycling process and lead to output streams with lower-quality fibres. Identification technology would enable automated sorting processes of garments by material content and colour. This would create control over the input into recycling processes and result in transparency on the output materials.³⁸⁵

When innovative materials are introduced, for example to increase garment functionality, it needs to be ensured that this does not reduce recyclability. E-/smart textiles that integrate advances in nanotechnology and electronics are expected to comprise a USD 130 billion market by 2025.³⁸⁶ The abilities of these technologies range from monitoring biometric data, such as heart rate, to changes in colour if harmful gases are present.³⁸⁷ Product labelling firm Avery Dennison aims to use RFID technology to digitise more than 10 billion clothing and footwear items and connect these with social network applications which, for example, would allow customers to share their outfits with friends or receive personal styling consultations from brands.³⁸⁸ Designers are also experimenting with new possibilities to enhance the aesthetics and functionality of clothing. For example, fashion-technology brand Elektrocouture includes LEDs in their clothes that are controllable by smartphone and can change colour.³⁸⁹ Designer Lilian Stenglein is offering a garment that uses a silver-based material that is odour-neutralising and also claims to protect the wearer from electric radiation caused by mobile phones.³⁹⁰

Creating industry-wide design guidelines would support process alignment and increase value captured through recycling. As upstream decisions such as material choices or labelling information will later impact the ability to sort and recycle clothing after use, clear design guidelines would facilitate greater value capture. Guidelines would need to consider aligning design of clothing with recycling options; convergence towards a reduced palette of materials; requirements for new material

innovations; and cross-industry alignment on systems for labelling, tracking, and tracing.

3.2.1. DESIGN AND DEVELOP CLOTHING AND RECYCLING TECHNOLOGIES IN A COMPLEMENTARY WAY TO ENSURE RECYCLABILITY

Reducing the complexity of materials used to produce textiles would allow recycling innovation efforts to focus on a small palette of materials optimised for both functional needs and recycling technologies. This would increase the amount of input for individual technologies and support swifter scaling.³⁹¹

Guidelines developed between designers, buyers, textile mills, and recyclers are needed to create alignment on clothing design and options for recycling items when they can no longer be worn. Industry efforts require coordination to avoid duplication or confusion for designers, which could stall the shift to alignment. Existing initiatives are starting to build links between designers and recyclers. For example, the research programme Trash-2-Cash is running a cross-disciplinary challenge to develop processes for indefinite chemical recycling of textiles. The project involves designers and material scientists early on to ensure usability of the recycled materials.³⁹² Brands, such as Vaude, Fjällräven, Houdini, Paramo have already changed the design of some of their garments to be made from 100% polyester, including zippers, buttons, and seams, instead of using different materials.³⁹³

Industry-led collaboration is needed to identify the materials for which there are no upcoming recycling solutions. Building an evidence base on commonly used materials and their recycling options would enable the development of guidelines that support convergence towards a smaller range of materials, and that focus efforts on recycling technology innovation. The industry has an opportunity to combine its efforts through information-sharing to build a comprehensive picture of the materials used throughout the system. Such efforts are already underway, for example Circle Economy, along with collectors, sorters, and recycling experts, is running the Fibersort project, which will result in an overview of the different material blends and the volumes of these that are used in

collected clothing in Europe.³⁹⁴ Fashion Positive has launched a collaborative membership programme called PLUS, bringing together a community of brands, designers, and suppliers to work together to “design circular fashion

from the materials up”. By building the Fashion Positive Critical Materials List, the group aims to identify high-volume, commonly used materials that require innovation as a priority to form part of a circular economy.³⁹⁵

BOX I: MATERIAL BLENDS

Blending is used to create fabrics that have the combined properties of their component fibres. Blended yarns are made by combining different fibres. Using material blends can improve the appearance, performance, comfort, and ease of care of a garment. Blending more expensive materials with cheaper fibres also reduces cost. One of the most common examples is ‘polycotton’, a blend of polyester and cotton. Compared to pure cotton, polycotton has a higher durability, crease resistance, and lower cost, but still maintains a cotton ‘feel’.³⁹⁶ Small amounts of elastane are blended with other fibres, mainly cotton, to add stretch to a garment.³⁹⁷ Acrylic is mostly blended with wool fibres to lower the cost.³⁹⁸ More complex blends of three or more materials are increasingly used as well, even in basic garments, including trousers made from 70% wool, 28% polyester, and 2% elastane,³⁹⁹ or a jumper composed of 43% polyamide, 20% acrylic, 19% mohair (a wool made from the hair of Angora goats), 13% wool, and 5% elastane.⁴⁰⁰

Even when clothing is labelled as 100% single material, it can still contain small quantities of other materials, and certain parts such as labels or sewing threads can be made from a different material.⁴⁰¹ For example, polyester stitching threads are usually used because of their strength and durability, even if the rest of a garment is made from cotton. Further investigation would be needed to understand the number of different blends employed by the industry, as well as the share of material blends.

Material blends make it more difficult to capture material value through recycling. Blends can be processed in mechanical fibre recycling processes, but this makes it difficult to control the material composition of the resulting recycled yarns. For chemical polymer recycling, technologies exist to separate blends as part of the recycling process, although separate steps are required and the processes are only feasible for materials that are used in large enough portions in the input material. Technologies at pilot scale exist for blends of polyester and cotton or other cellulose-based materials. Materials that usually occur in very low quantities, such as elastane, can be part of the input to those processes but are lost as leftover sludge.

When biodegradable fibres (such as cotton, other cellulose-based fibres, or wool) are mixed with non-biodegradable fibres (such as polyester, acrylic, nylon, or elastane), this creates another challenge. The resulting yarn of such a mix is no longer biodegradable and so is unsuitable for value retention in biological cycles (see Box C, p.51) even if the amount of added non-biodegradable fibres is minimal, for example in the aforementioned elastane blends.

Materials innovation can address such challenges. For instance, underwear manufacturer Wolford, has created Cradle to Cradle certified hosiery and lingerie that can be safely biodegraded. The garments use cellulose-based fibres, biodegradable plastic-based Infinito fibres, and stretch is created by using Roica Eco Smart, an innovative material designed to replace traditional elastane.⁴⁰²

3.2.2. INNOVATE NEW MATERIALS WHERE GAPS EXIST

Guidelines on a materials palette optimised for recycling would identify the need for innovation of new materials. The development of guidelines to only use materials that can be recycled will reveal gaps where existing materials offer a specific function, but are unlikely to be economically recyclable after use. Collective action by designers, material experts, and recyclers is needed to identify where innovation efforts should focus to find alternative materials that can be economically recycled. Innovators seeking new materials could work in collaboration with retailers, manufacturers, and

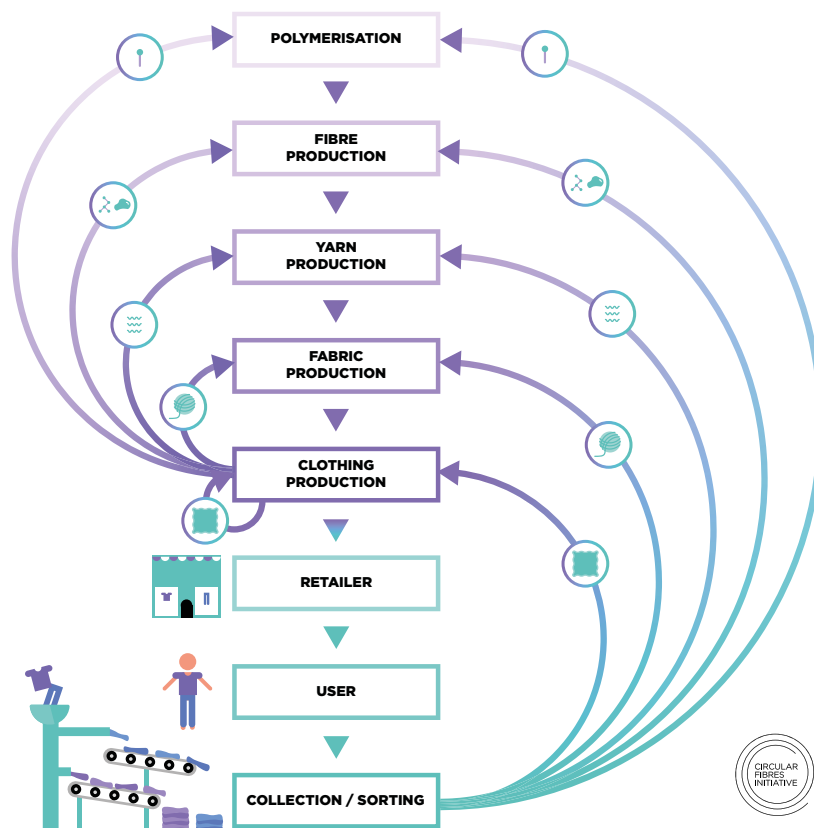
recyclers to understand functional requirements and ensure ultimate recyclability.






Once promising new materials are identified, these must be brought to the market. Brands can support small innovators to overcome the higher costs associated with smaller-scale and less well-established supply chains and processes by stimulating interest and securing investment. The fast pace of fashion cycles requires suppliers to deliver fabrics within one or two months of ordering, yet innovators can find it difficult to deliver on such short time frames.⁴⁰³ Companies that have longer lead times offer a prime opportunity to partner with small-scale innovators to bring new materials to market.

BOX J: DIFFERENT TYPES OF RECYCLING

Through recycling, material value of textiles can be captured at different levels (see Figure 17). As materials are cycled further up the value chain, the retained inherent value decreases. All of the technologies may be applied to offcuts from clothing production as well as unwanted garments collected after use.

FIGURE 17: TEXTILES RECYCLING CAN CAPTURE VALUE AT VARIOUS LEVELS



<p>FABRIC RECYCLING</p> 	<p>Fabric recycling takes pieces of complete fabric and re-sews them to create (parts of) a new garment. This level of recycling is sometimes also referred to as 'remanufacturing'. It can take the form of utilising factory offcuts and leftover materials, or large parts of post-use garments that are disassembled and reused in a new garment while keeping the fabric intact. If a change in colour is needed, the fabric can be treated with bleaches or dyes in the process. This type of recycling does not require advanced technologies, but only has limited applications as it is labour intensive, inconsistent supply of fabrics will not allow for large-scale production, and the fabric is often too small to be made into another garment or the quality is too low.</p>
<p>YARN RECYCLING</p> 	<p>Yarn recycling refers to the unravelling of the yarns used to make knitted garments. To be able to unravel a garment, it must be knit in a way that makes it possible to get the yarn back in a small number of pieces. Therefore, yarn recycling is only feasible for specific types of garments, which need to be collected separately or separated out.</p>
<p>FIBRE RECYCLING</p> 	<p>For fibre recycling, garments are sorted by colour and material, and then shredded and processed back into fibres. This level of recycling is often referred to as 'mechanical recycling'. The fibres are shortened through the shredding and thus deteriorate in quality.⁴⁰⁴ This quality loss makes it necessary to use higher-quality fibres (current solutions to this often use virgin cotton or polyester recycled from sources such as PET bottles) as a supplement for creating new yarn. By design, fibre-recycling processes cannot separate blends or filter out dyes and contaminants. This causes problems where any substances of concern are retained in the textiles, as recycling these in the fibres can lead to the continued circulation of – and therefore exposure to – these substances.⁴⁰⁵ Textiles that were placed on the market before current regulations can contain significantly higher amounts of certain substances of concern than virgin materials, where the use of these substances is restricted.⁴⁰⁶ If garments are sorted by colour, no bleaching or re-dyeing is needed, however it is possible if a different colour is wanted.</p>
<p>POLYMER RECYCLING</p> 	<p>Polymer recycling takes fibres back to the polymer level, destroying the fibres but keeping the chemical structure of the material intact. There are two variants that are different in terms of process and output quality.</p> <ul style="list-style-type: none"> • Mechanical polymer recycling. Mechanical polymer recycling is carried out via melting and extruding of textiles made from mono-material plastic-based fibres. By design, this process cannot filter out dyes and contaminants, such as substances of concern. As with fibre recycling, no bleaching and re-dyeing is needed, however it is possible if a different colour is wanted. • Chemical polymer recycling. Chemical polymer recycling dissolves textiles with chemicals after the garments have been de-buttoned, de-zipped, shredded, and in some cases de-coloured. This technology can be applied to plastic- and cellulose-based fibres or a mix of both. Cellulose – the polymer that is the main component of cotton – and polyester are extracted separately for further treatment. Cellulose pulp can then be transformed into new cellulose-based fibres and plastic polymers are treated separately to bring them to back to virgin-equivalent quality. Dyes, non-target fibres in small quantities, and other contaminants can be removed during the process.
<p>CHEMICAL MONOMER RECYCLING</p> 	<p>Chemical monomer recycling breaks down polymers into individual monomers or other constituent materials that can then serve as feedstock to produce virgin-quality polymers. Dyes, non-target fibres in small quantities, and other contaminants can be removed during the process.</p>

3.2.3. DEVELOP GUIDELINES FOR TRACKING AND TRACING TECHNOLOGY TO IDENTIFY AND EASILY RECOVER MATERIALS

Adopting product passports and materials labelling at the design stage would improve material recovery. Digital technologies can support more accurate sorting of textiles through increased access to information, however, it is key that these are considered in the design or manufacture stage to be used effectively.

For example, the company Content Thread is researching the applicability of an RFID thread attached to individual garments at the manufacturing stage that contains a digitised ingredients list. The thread looks and feels like a normal thread and is still detectable after a long use.⁴⁰⁷ This step would provide recyclers with all the information needed to sort and recycle the garment accordingly. Global common guidelines on clothing labelling would be required to ensure universal application to sorting of any material streams. Guidelines would also need to include information on the integration of new technologies, such as e-textiles or RFID, in a way that enables easy disassembly and recovery after use. Technology company Applied DNA Sciences has created a bio-based marker that can be sprayed onto cotton, allowing individual fibres to be tracked and identified throughout the value chain. The company claims this can provide assurance on the origin of the cotton and the composition of the material.⁴⁰⁸

Blockchain technology is an example of how digital advances improve transparency and provide sorters, collectors, and recyclers with reliable information on material composition of garments.⁴⁰⁹ This technology is already employed in other industries, including banking. London-based designer Martine Jarlgaard partnered with digital company Provenance to use blockchain technology to successfully track the journey of an alpaca jumper from the farm to the finished garment.⁴¹⁰

3.3. Pursue technological innovation to improve the economics and quality of recycling

The economics and output quality of existing recycling technologies for common materials need to be drastically improved to capture the full value of materials in recovered clothing. A shared innovation agenda is needed to focus efforts and investments on recycling technologies for common materials. Improved sorting technologies are also needed to provide high-quality feedstock to recyclers. Radically improving clothing-to-clothing recycling will require effective infrastructure globally for collection, tracking and tracing, sorting, and recycling.

3.3.1. RADICALLY IMPROVE THE ECONOMICS AND OUTPUT QUALITY OF RECYCLING

Technical innovation presents an opportunity to address a significant bottleneck in the shift towards a new textiles economy, by providing solutions that can offer recycled materials which can compete with virgin materials on cost and quality.⁴¹¹ There are a range of ways in which clothing can be recycled (see Box J), and each of these have different opportunities and challenges related to cost, the appropriate output quality, and scaling.

Fabric recycling. Fabric recycling of production offcuts is relatively widely adopted already. For example, companies like Nurmi clothing, Reformation, Ahlma, and Looptworks use leftover materials from factories to make clothes, as these fabrics are high quality and do not have complicated trimmings such as buttons or seams to remove.⁴¹² Finnish fashion chain Lindex produces new collections using unsold denim garments from previous seasons that are then redesigned and remade into new garments; this ranges from small adjustments such as new details, to completely taking apart and sewing fabrics back together to create a new product.⁴¹³ Digital start-up Reverse Resources have developed a software-as-a-service to reduce

and make better use of factory offcuts, including for fabric recycling (see Case Study C, p.114).

At small scales, fabric recycling also exists for materials collected after use. While this type of recycling is unlikely to provide the consistency needed for large production runs, there is increasing appetite from small designers to make bespoke garments from this leftover material. For example, clothing brand Eileen Fisher set up its “tiny factory” to make new garments from used clothing, when it was faced with large amounts of clothing it had previously collected from customers that was not suitable for resale.⁴¹⁴ Innovations, such as C-Tech’s Wear2 microwave technology, can enable such recycling by making disassembly a lot easier. The company has developed a yarn that dissolves when put in a microwave, allowing leftover fabrics to be recycled.⁴¹⁵

Yarn recycling. While simple in theory, the concept of yarn recycling is largely unexplored in practice and is not found at scale in the industry today. Difficulties in producing a garment from just one yarn that would not potentially unravel by itself would need to be addressed for this concept to be scaled. However, it is possible that a technological solution could be found for this through increased automation and 3D knitting. Clothing company Benetton has implemented such a design, enabling yarn recycling with its single-thread knitwear produced using a special high-tech Japanese knitting machine and just one 450-metre-long yarn.⁴¹⁶ Further research is needed to explore the opportunities that this type of recycling could bring and to develop the relevant technologies.

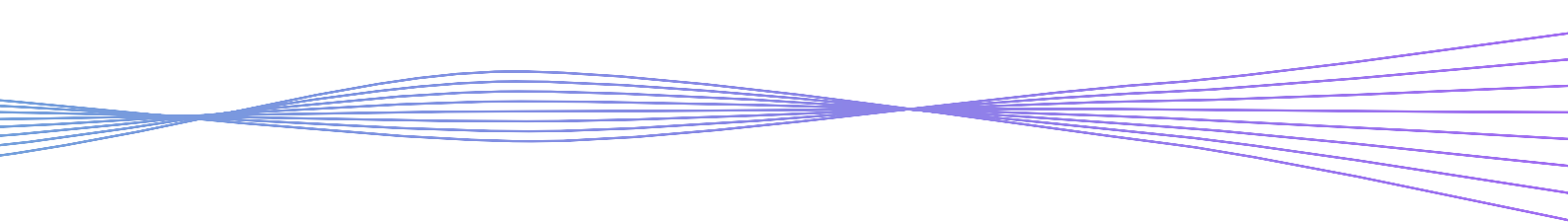
Fibre recycling. This type of recycling has been used for nearly 250 years and is applicable at scale through standardised mechanical process.⁴¹⁸ Resource needs for chemicals, dyes, and water are minimal as there is often no need for bleaching and re-dyeing because textiles are normally sorted by colour. However, fibre recycling does not currently offer the quality of recycled fibres needed to produce a 100% recycled garment from the output, except for wool that is recycled for the first time.⁴¹⁹ This is due to shortening of the fibres in shredding. Therefore, to provide the quality needed for use in a garment, recycled cotton is usually blended with longer fibres, which are mostly virgin cotton or, for cost reasons, polyester. Currently, the amount of recycled cotton in yarn varies

from 20% to 90%, depending on application.⁴²⁰ Fabrics that need to be robust, such as denim, currently only use around 20% recycled cotton from used clothing,⁴²¹ although recent technological improvements have managed to increase this to 40%.⁴²² A higher share of recycled fibres can be achieved when factory offcuts are used, as the quality of the fibre deteriorates during use.⁴²³

For example, textiles recycler Hilaturas Ferre offers a yarn made of 90% recycled cotton and 10% other fibres, which can be polyester, nylon, acetate, linen, viscose, or wool.⁴²⁴ The use of recycled wool and wool blends as feedstock is already established, mainly as it can be 30–40% cheaper than virgin wool,⁴²⁵ and technologies are in use, for example, by recycler Wolkat and wool manufacturer Geetanjali.⁴²⁶ Wool producers in the city of Prato, Italy, have also used wool scraps to produce cheaper garments, rebranding it as “regenerated wool”.⁴²⁷ The company 3C Filati even claims to offer a “100% recycled product”.⁴²⁸

Mechanical polymer recycling. Mechanical polymer recycling only works for single-variety plastic-based fibres, and is currently most promising as a solution for polyester recycling. Companies that have control over their materials have a significant opportunity to capture value through this type of recycling. For example, clothing company Dutch Awearness develops workwear that guarantees a pure material input for the recycling process, enabling the same feedstock to be recycled several times.⁴²⁹ Despite being technologically feasible, the process is not yet applied at scale. Yet, there is a clear opportunity for scale-up, as it is price competitive with virgin polyester and, importantly, not subject to the same price volatility as the virgin material.

Chemical polymer recycling. Both cotton and other cellulose-based fibres (e.g. lyocell, viscose) as well as plastic-based fibres, such as polyester, can be recycled using solvent-based technologies. Chemical polymer recycling of cotton is already at a commercial level, while technologies are also being developed for blends, and are moving from R&D stages into pilot and industrial developments. Scaling up adoption of chemical recycling technologies additionally could be supported by creating transparency on the materials in the system, as well as coordinating innovation efforts.



For pure cotton, the result of the current chemical polymer recycling process to recycle cotton is a cellulose pulp which can be used to produce other regenerated cellulose-based fibres. The recovery process is theoretically repeatable several times but currently the polymer chain degrades with each repetition. Research shows that the quality also deteriorates during use, which suggests that at some point the quality will be too low for further application in apparel.⁴³⁰ More research is needed to better understand the applicability of this process for multiple cycles, for example how low-quality fibres can be detected and treated.

Several examples of this type of recycling already exist for pure cellulose-based fibre material streams. For example, fibre manufacturer Lenzing's Refibra product, made by recycling cotton scraps from factory offcuts and combining them with wood to create a new lyocell fibre, is already commercially available.⁴³¹ Other pioneers, such as recycler Re:newcell and The Infinited Fibre Company are piloting technologies to recycle textiles made from cotton and other cellulose-based materials into new cellulose-based fibres.⁴³² Evrnu has developed prototype jeans and T-shirts using post-use recycled cotton, working with partners such as Levi's and Target.⁴³³

Promising solutions are also emerging to address the challenges of recycling material blends. For example, recycling start-up Worn Again has developed a process that can separate and recapture polyester and cotton from pure and blended materials into virgin-equivalent polyester and a cellulose pulp that can be used to produce lyocell or viscose. The process can take up to 20% of additional material, which gets filtered out, and the company claims that the vast majority of non-wearable textiles are suitable as feedstock into their process. Research to valorise these filtered-out materials, for instance dyes and elastane, is underway.⁴³⁴ The Hong Kong Research Institute for Textiles and Apparel in partnership with the H&M Foundation also recently developed a new process to separate cotton-polyester blends.⁴³⁵ Such innovations represent the opportunities for this type of recycling, but further alignment and widespread adoption would be needed to ensure that the real benefits of these emerging technologies are realised.

Chemical monomer recycling. Currently, monomerisation technologies only exist for plastic-based fibres. Polymers like polyester and polyamides (e.g. nylon) can be depolymerised to extract the monomers from which they have been produced.⁴³⁶ These can then be used as building blocks for the production of new polymers. Technologies are mature and proven for both polyester and nylon, but not yet widely adopted for clothing.⁴³⁷ For polyester this is partly due to a lack of cost-competitiveness compared to virgin polyester. However, as they bring plastic-based end-of-use materials back to virgin quality, these technologies could be the method of choice for materials of such low quality that there are no other viable recycling alternatives. Industry efforts are needed to create cost-competitive processes for polyester fibres, and to explore monomer recycling for cellulose-based fibres. Currently, RESYNTEX, an EU collaboration project, is researching such opportunities for cotton, PLA, PET, and wool.⁴³⁸

There have been some significant successes for certain materials. In 2011, leading manufacturer Aquafil created a Nylon-6 yarn called ECONYL from 100% recycled materials. The yarn is created from post-use materials from carpets and factory offcuts from the production of various textiles, including clothing. The recycled fibre is then used in apparel, for example for swimwear or stockings.⁴³⁹ Japanese chemical company Teijin produces a chemically recycled polyester under its Eco Circle brand.⁴⁴⁰

Chemical monomer recycling for polyester is not yet cost competitive, mainly because separating out the monomers from the dyes, coatings, and other contaminants is costly and energy intensive. For example, recycled polyester from unwanted clothing commanded a 20-30% price premium compared to virgin polyester in a Patagonia project,⁴⁴¹ while the *Pulse of the fashion industry* report found chemically recycled polyester to be 10% more expensive than virgin.⁴⁴² However, recycling innovators like JEPLAN have started to invest into polyester monomerisation, indicating that they can see a business opportunity in the sector.⁴⁴³ Ioniqa has developed a process to recycle different kinds of PET, including polyester from clothing into monomers. They claim that their product – once the process is scaled up – will be cost competitive with virgin material.⁴⁴⁴

3.3.2. IMPROVE AND SCALE SORTING TECHNOLOGIES TO DRASTICALLY INCREASE RECYCLING OUTPUT QUALITY

Once clothing is collected, effective sorting and identification of garments into separate streams appropriate for different recycling systems is required. As mentioned above, accurate and rapid sorting of garments would be greatly supported by universally aligned tracking and tracing technology. Until this is implemented at scale, continued development and introduction of optical sorting technologies could improve the speed of garment sorting, which is mostly carried out manually today.

According to WRAP, automated optical sorting technologies play a critical role in scaling up recycling and making it cost competitive with virgin resources.⁴⁴⁵ While automated garment sorting technologies exist, their current accuracy and speed at sorting complex materials limits their application.

Promising technologies using Near Infrared (NIR) technologies such as hyperspectral imaging and visual spectroscopy (VIS) are currently being developed, which can sort clothes by colour and material category. Some of these technologies can currently reach sorting speeds of up to one garment per second; however, multicoloured garments pose a difficulty, as only certain areas of a garment are scanned to identify it.⁴⁴⁶ Three projects currently developing these technologies are discussed below.

- Machinery manufacturer Valvan's NIR spectroscopic technology, called the FIBERSORT, can detect garments made from cotton, wool, viscose, polyester, acrylic, nylon, and certain blends of these fibres, as well as sorting by colour at the same time.⁴⁴⁷ The FIBERSORT possesses an extensive database of today's materials. After the scan, the captured image is analysed and compared to the database to determine the fibre type.⁴⁴⁸ It can process up to one garment per second. However, there are still challenges in sorting complex blends of three or more materials.⁴⁴⁹
- The EU-funded Resyntex project will build a demonstration NIR-based textile recognition plant at SOEX's premises that can sort, pre-treat, and biochemically process

different pure and blended input textiles. The plant will be able to handle 500 tonnes of garments per year, around one garment every ten seconds. The technology is yet to be improved in terms of the number of different colours, materials, and blends that it can detect.⁴⁵⁰

- SIPTex, a Swedish consortium led by IVL Swedish Environmental Research Institute, is currently undertaking operational tests for automated sorting of textiles for recycling using NIR and VIS technologies. In a pilot facility, textiles are sorted according to their different materials and colours. Rather than separating for exact fibre compositions, the machine sorts for the majority fibre type of each garment. Once a garment's type is identified, compressed air separates it from remaining textiles.⁴⁵¹

3.4. Stimulate demand for recycled materials

Increasing demand for recycled materials could drastically speed up the development towards circularity in the apparel sector. Driving up demand for recycled materials would bring economies of scale and inspire innovation to improve their quality. Enhanced transparency, together with matchmaking mechanisms that connect designers and buyers with producers of recycled materials, coupled with strengthened 'pull' effects that generate demand for recycled materials could lead the way.

3.4.1. STRENGTHEN THE 'PULL' EFFECT ON THE DEMAND SIDE THROUGH VOLUNTARY COMMITMENTS AND POLICY

Brands could contribute towards increasing the amount of clothing-to-clothing recycling by making commitments to use recycled materials. This would stimulate and guarantee a certain demand and generate a 'pull' effect to improve recycling.

Since technologies are still under development this might mean higher material costs in the short term. However, large-scale adoption in the industry could quickly lead to economies



of scale. Commitments are already in place. The Global Fashion Agenda's call to action for a circular fashion system has been signed by 64 fashion companies, representing 143 brands. With a combined total revenue of USD 133 billion, the signatories represent approximately 7.5% of the global fashion market. The signatories have committed to defining a strategy, setting targets for 2020, and reporting on the progress of implementing the commitment. One of the four concrete actions on the agenda is to increase the share of garments made from recycled textile fibres.⁴⁵²

Some brands have also put their own targets in place. For example, H&M has set a commitment to use 100% recycled or "other sustainably sourced materials" by 2030.⁴⁵³ C&A has committed to the goal that 67% of all of its raw materials will be sourced from "more sustainable sources" by 2020.⁴⁵⁴ Kering has committed to reducing its environmental profit and loss across its supply chain by 40% by 2025 by tackling the impact of their sourcing, manufacturing, and operations.⁴⁵⁵

Public procurement could serve as a frontrunner and have a significant impact.

Public procurement represents a significant amount of purchasing power. In Europe, for example, it amounts to 14% of GDP.⁴⁵⁶ Hence, procurement guidelines that provide buyers with the information needed to favour recycled materials in their sourcing decisions can lead the way towards a greater uptake of recycled materials for clothes through large-scale orders. Progress towards such guidance is underway by the European Clothing Action Plan (ECAP), which is currently researching the role of public procurers and aims to publish a report helping them to reach environmental goals by using their buying power to stimulate a circular approach to workwear.⁴⁵⁷ Public procurement offers the ability to stimulate market demand. For example, Dutch government agencies purchase EUR 102 million (USD 120 million) a year of workwear, which represents 1% of overall Dutch expenditure on clothing.⁴⁵⁸ The Netherlands has introduced a programme called A Circular Economy in the Netherlands by 2050, which set the target of a 50% reduction in raw materials use by 2030.⁴⁵⁹ The Dutch Enterprise Agency, which is part of the Ministry of Economic Affairs, has also included the use of recycled fibres as a beneficial criterion for sourcing workwear.⁴⁶⁰ For end-of-use solutions,

the Danish municipality of Herning has included finding commercial recycling solutions for used work clothes in their objectives for procurement.⁴⁶¹ Such examples show how government stimulus and public procurement can lead the way in a system-level shift.

Policymakers also play an important role in stimulating demand by incentivising the use of recycled materials and/or disincentivising the use of virgin materials. For example, policy could come in the form of Extended Producer Responsibility (EPR). EPR policies give producers significant responsibility – financial and/or physical – to treat or dispose of their post-consumer products.⁴⁶² In comparison to voluntary schemes, mandatory policies have the advantage of targetting the entire industry equally.

France introduced a law in 2006 that obliges companies to provide or manage recycling options at their products' end-of-use. The intention of the law is to encourage producers to consider what happens to their products when they cannot be used anymore. They can either run their own programme to do this or contribute to an organisation that provides the service on their behalf. Either programme must be approved by the French public authorities. Non-profit ECO TLC is currently the only organisation accredited to provide such a service for textiles. Contributions paid to ECO TLC are used for research into recycling technologies, communication campaigns aimed at customers concerning waste-sorting habits, measuring tools to analyse industry statistics, and real-time collection site mapping. Contributions are paid by the item and vary by size (from EUR 0.00132 (USD 0.00155) for the smallest items to EUR 0.0528 (USD 0.0622) for the largest items). To incentivise companies to use recycled input, these fees are reduced if a certain minimum amount of recycled material is used in a company's production processes.⁴⁶³

Policymakers can increase the uptake of recycling by removing regulatory barriers. For instance, the EU defines used textiles as waste, and its strict rules on the transport, storage, and treatment of waste pose challenges for collection and recycling efforts. This has already been recognised as a problem and a proposal as part of the European Commission's Circular Economy Package suggests reclassifying recycled materials as non-waste whenever they

meet a set of general conditions.⁴⁶⁴ In addition, many countries employ some kind of ban or restriction on imports of used clothing.⁴⁶⁵ For example, China recently banned the import of waste textiles.⁴⁶⁶

3.4.2. CREATE TRANSPARENCY AND COMMUNICATION CHANNELS TO BETTER MATCH SUPPLY AND DEMAND

Increasing the transparency of recycled material properties and user specifications would enable better matching of supply and demand. Open dialogue between recyclers, textile mills, and brands could facilitate alignment on the key properties required for materials in different applications. While brands often do not incorporate recycled materials in their products due to lower quality and/or higher prices compared to virgin materials, recyclers claim that brands follow such strict material specifications that recycled materials cannot compete with virgin quality.⁴⁶⁷ According to fibre recycling companies, recycled fibre's quality cannot be compared to virgin fibre, yet it can still sufficiently fulfil the requirements of most clothing applications.⁴⁶⁸ Increased transparency on the specification of materials from brands, and also on the properties of recycled material, could support matchmaking of buyers with suppliers. This could have the added impact of increased trust in the supply chain, and support the development of long-term relationships with the manufacturers providing the recycled materials. These relationships would then enable adoption at scale and further improve economics in the recycling system. Material scientists need to consult brands and retailers on sufficient quality levels for different clothing applications to decrease the level of uncertainty around the capabilities of recycled fibres, and thus increase their rate of uptake.

The Global Recycled Standard (GRS), managed by Textile Exchange, is one such effort looking to increase confidence in recycled materials, by certifying the integrity of the final product as having been recycled according to ISO norms. This includes monitoring social and environmental criteria of the facilities together with obedience to chemical restrictions.⁴⁶⁹ The Recycled Claim Standard (RCS) operates in a similar way, but does not include the additional

processing criteria.⁴⁷⁰ Such standards can serve as an independent reference for quality assurance.

A matchmaking platform could be established to support the uptake of recycled materials.

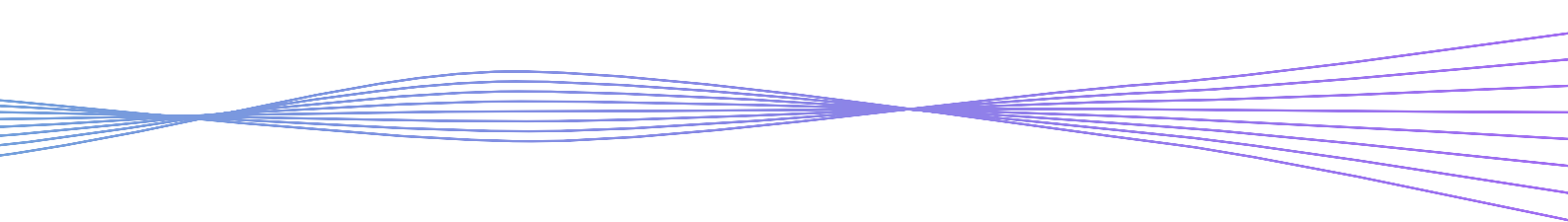
A platform that brings together suppliers and buyers of recycled materials could support easier connections and facilitate greater transparency and better alignment between supply and demand. Buyers could more easily evaluate the options for recycled material and suppliers would be able to offer the materials to a larger, more focused audience. Examples of such platforms already exist. Circle Economy's Circle Market, an online trading platform that connects the supply and demand of excess textiles, is currently being piloted with a number of companies globally.⁴⁷¹

3.5. Implement clothing collection at scale

Clothing collection needs to be scaled up dramatically alongside recycling technologies and, importantly, implemented in locations where it currently does not exist. Creating demand for recycled materials, as discussed above, will increase markets for non-wearable items, and therefore dramatically improve the opportunity for collectors to capture value from these materials. Guidelines based on current best practices and further research on optimal systems could help scale up collection. Such guidelines may be applied to a set of country or city archetypes, allowing for regional variation but building on a set of common principles.

Various clothing collection schemes exist with large variations between different regions

A variety of systems currently exist to collect used clothing (see Table 1 for an overview). Collection rates, and the type of schemes to collect used textiles, vary significantly, both nationally and regionally. Some countries, such as the UK, have municipal collection schemes, but these vary by local district. Yet, while in countries like the UK and Germany there is often










a choice between various ways of disposing of reused clothes, many other countries do not have any formal collection at all and rely solely on informal collection systems. Some of these systems do not distinguish between clothes collected for recycling and reuse (see Box K) and further investigation is needed to better understand the advantages and disadvantages of mixed or separated collection.

Where collection schemes do exist, the collection landscape for clothes recycling after

use is often characterised by fragmentation, lack of scale, and lack of location-appropriate collection systems. Systems across retailers, charities, and municipalities require expansion and scaling up. A number of retailers – including Patagonia, Zara, and H&M – have already introduced their own take-back schemes. For example, H&M’s Recycle Your Clothes initiative, launched in 2013, has so far collected 45,000 tonnes of clothes and has set itself a target of scaling up to 25,000 tonnes annually by 2020.⁴⁷²

TABLE 1: METHODS OF CLOTHING COLLECTION

COLLECTION TYPE	DESCRIPTION	EXAMPLES	MAIN ADVANTAGES	MAIN DISADVANTAGES
 MUNICIPAL WASTE COLLECTION	Garments are collected through municipal waste collection	Most countries	High convenience Suitable for large scales	Textiles mixed with other waste need to be separated out and also accumulate dirt from other waste
 SINGLED-OUT KERBSIDE COLLECTION	Separate kerbside collection of unwanted clothes	Some municipalities including in the US, UK, and China ⁴⁷³	Potential for large scale	Households need to separate out clothing for collection Separate logistics needed
 HOME PICK-UP	Ordered courier collects textiles	British Heart Foundation ⁴⁷⁴	High convenience for user Can be combined with return of rented items	Work-intensive and tailored routing needed
 NEIGHBOURHOOD COLLECTION CONTAINERS	Users take garments to local collection containers	Red Cross, ⁴⁷⁵ TEXAID, ⁴⁷⁶ San Francisco ⁴⁷⁷	Relatively convenient if container density is high Large scale possible	Separate logistics needed
 BRAND MAIL-BACK	Users are asked to mail their unwanted clothes back to brands	Patagonia, ⁴⁷⁸ Eileen Fisher ⁴⁷⁹	Can be combined with incentive system	Users have to mail items
 RETAILER DROP-OFF	Users bring garments back to retailer	H&M, ⁴⁸⁰ Zara ⁴⁸¹	Can be combined with incentive system Large scale possible	Users have to remember to take items along
 CHARITY SHOP DROP-OFF	Users take garments to charity shops	Oxfam, ⁴⁸² Red Cross, ⁴⁸³ British Heart Foundation ⁴⁸⁴	Implicit incentive system Large scale possible	Users have to bring items to a shop

While improved recycling technologies will help, investment and further research is required to scale up collection efforts

Collection, sorting, and recycling processes need to be scaled up at the same time, to create demand and improve the economic attractiveness of collection. While factory offcuts are, most often, easily available for recycling collection, additional infrastructure and processes are required to collect clothing after use.

Implement after-use clothing collection where it currently does not exist. More than half of all clothes worldwide are sold in Europe, North America, and China, but 10% of these end up

in other countries after their use.⁴⁸⁵ This means creating clothing collection systems tailored to those destination countries – most of which do not currently have formal collection systems – to capture material value even from clothes sold in other places.

Increase the uptake of existing clothing collection schemes. In countries where used clothing collection already exists, barriers need to be addressed to further scale these initiatives. This would require actions to improve the economic incentives for collectors and make it more convenient for users to keep materials in the system. Further understanding of the advantages and disadvantages of the existing schemes is needed to facilitate their expansion.

BOX K: CLOTHING COLLECTION FOR REUSE

In some high-income countries, large proportions of clothes discarded by local customers are collected through a variety of channels. Nearly 70% of the clothes collected in Europe and the US overall is considered reusable.⁴⁸⁶ Only 20% of these collected clothes is actually resold on domestic markets, due to the lack of demand.⁴⁸⁷ The rest is sold to textile merchants who sort and ship them overseas, and, of these, 70% is actually reused. With regard to the remainder, two-thirds are cascaded to lower-value applications and one-third is landfilled or incinerated.⁴⁸⁸

While this model has increased value capture and utilisation of clothing, it is not a long-term solution since it will lead to saturated markets in recipient countries. In Uganda, for example, second-hand garments already account for 81% of all clothing purchases.⁴⁸⁹ A case study of used clothing exports from Nordic countries to Malawi highlighted the lack of infrastructure for waste collection in general and revealed that a high focus on the material value of products ensured that textiles are used until all possible value is drawn out, after which they are often disposed of in the environment.⁴⁹⁰ While such reuse schemes increase the utilisation of the material significantly, residual value is still ultimately lost from the system.

This leads to several key considerations for clothing collection schemes for reuse:

- Since it increases clothing utilisation, collection for reuse could play an important role in a new textiles economy – at least in the medium term, until resale models have been more widely adopted (see Section 2.3.3).
- The potential to scale up the existing collection for reuse model is limited. For example, copying the systems in place in countries like the UK and Germany and rolling them out worldwide without creating new resale models (see Section 2.3.3) would not be feasible, due to the lack of markets in which to sell these collected clothes.
- Greater collection for reuse in some countries does not replace the need to scale up collection systems globally – particularly in regions where they do not yet exist – and to scale up recycling. In a new textiles economy, the material in clothes that have been worn until they cannot be worn anymore should be recovered and recycled.

3.5.1. DEVELOP GUIDELINES TO SUPPORT IMPLEMENTATION OF AFTER-USE CLOTHING COLLECTION

A set of global collection archetypes, allowing for regional variation but building on a set of common principles, could support the scaling-up of clothing collection after its final use and the implementation of systems where there are currently none.

Guidelines could support alignment between collectors and sorters when working together to realise value-capture opportunities and also align collection and recycling facilities globally, to better connect the material streams to the recycling facilities and create a closed-loop system. Efforts to develop the guidelines would need to address fundamental questions about how to collect and sort clothing streams for recycling. For example, they would need to explore whether to separate clothes for reuse and recycling at source, or whether to collect all clothes together and separate afterwards.

Pilot schemes can be used to test and select the most successful collection methods that captured the highest value, before scaling these up to regional or national levels. Research is needed in several areas to develop such recommendations.

Investigate locally appropriate collection systems for after-use clothing globally. To introduce recycling collections for after-use clothing where these currently do not exist, efforts to better understand local cultures and material flows would be needed. There is a general lack of information about what happens to used textiles when there is little or no collection infrastructure, and the overall impacts of this.⁴⁹¹ Building transparency and understanding current practices would support the development of locally suitable collection schemes in places where clothes are worn for the last time.

Investigate cost-effective means of collection. To make the implementation of clothing collection more economically attractive for collectors, it is crucial to keep the cost of collecting low. Costs associated with collection include transport and sorting. Innovation in technology could reduce costs through faster loading and unloading of collection vehicles and by mechanisation and software-supported

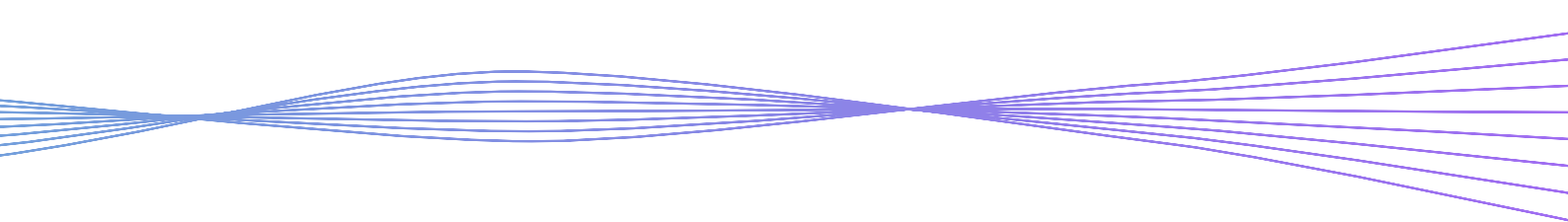
management of collection routes, which could help optimise asset utilisation, fuel consumption, and labour deployment.

Understand the advantages and disadvantages of different collection schemes. There are a variety of ways to collect clothing after use, including local authority collections, textile 'bring banks', civic amenity centre collections, donations directly to charity shops, in-store retailer collections, door-to-door charity bag collections, and 'cash for clothes' donations (see Table 1).⁴⁹² An examination of these different methods should also include which factors are most important to incentivise use of existing systems. While further research is needed, three factors contribute to the uptake of collection systems, and should be considered when creating or scaling collection schemes:

- **Convenience.** Encouraging uptake of clothing collection schemes requires infrastructure that is easy to use. Given the subjective nature of, and cultural differences in, what is considered convenient this could require offering a combination of options for collection.
- **Awareness and trust.** To avoid textiles being sent through the wrong channels, doubts about after-use treatment must be removed.
- **Incentives.** These are most commonly monetary, although compensation also comes in other forms such as the 'feel-good factor' when donating used clothes. Collection solutions provider I:CO offers a range of collection options that reward people for returning their clothes and have supported in-store collection schemes, like that of fashion giant H&M, which attract participants with discount vouchers for in-store purchases.⁴⁹³

3.5.2. EXPLORE THE ENABLING ROLE OF POLICY

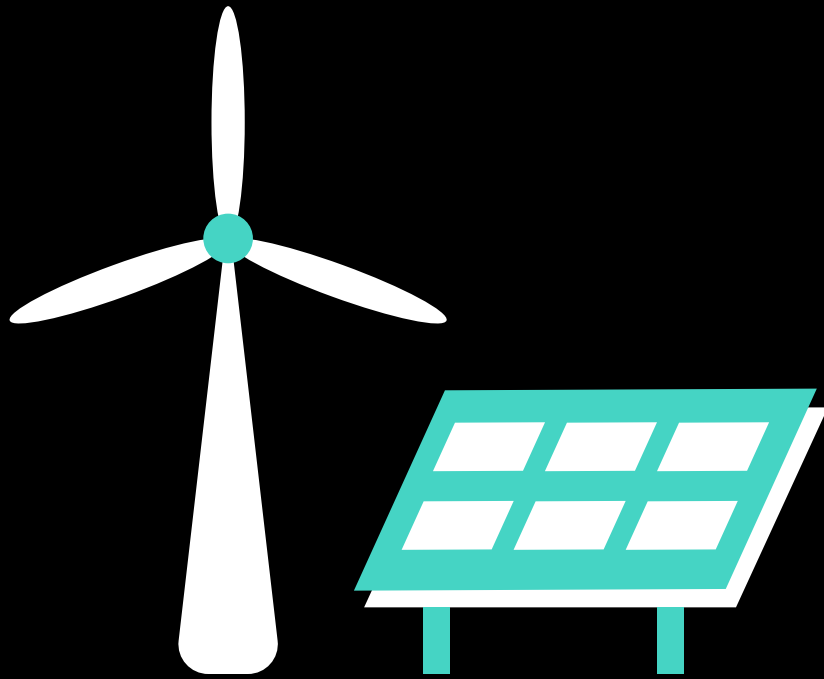
Policymakers at various levels play roles in scaling up clothing collection. Directly, policymakers responsible for waste management – usually at the municipal level – could invest or incentivise investment in infrastructure, for example by pursuing public-private partnerships. This could speed up the implementation of the necessary collection infrastructure where it currently does not exist or create additional and better schemes to



increase uptake, for example through running pilots in partnership with brands.

Other options at the disposal of policymakers to help scale up clothing collection include setting targets or incentives for collection, extending producer responsibility schemes (see Section 3.4.1), removing barriers caused by the definition of used textiles as waste, and

removing barriers to trade such as import or export bans. Collection rates could be rapidly increase by 'push' mechanisms. These could include charging for clothing discarded in the general waste bin (while not charging for separate collection), or banning textiles from landfill and incineration altogether.



4. Make effective
use of resources
and move to
renewable inputs



4. MAKE EFFECTIVE USE OF RESOURCES AND MOVE TO RENEWABLE INPUTS

A new textiles economy would be regenerative and restorative, phasing out the use of non-renewable resources. Replacing non-renewable resources with recycled feedstock (Ambition 3) and reducing throughput in the system by maximising clothing utilisation (Ambition 2) are key contributors in significantly reducing resource usage. However, virgin material input will likely always be required. Where such input is needed and no recycled materials are available, it should increasingly come from renewable feedstock produced in regenerative ways. In addition, transitioning to more effective and efficient production processes that generate less waste, need fewer inputs of resources, such as fossil fuels and chemicals, reduce water use in water-scarce regions, are energy efficient, and run on renewable energy, can further contribute to reducing the need for non-renewable resource input.

In addition to being essential for a system that works in the long term, achieving this ambition would allow the industry to reduce risks related to resource price volatility and security of supply, and to capture value through direct cost savings. Four key actions have been identified to support a more effective use of resources and move to renewable inputs: accounting for the costs of negative externalities to incentivise good systems-level resource management; finding sources for renewable feedstock where resource input is needed; removing barriers to adopt more effective textiles production methods at scale; and innovating processes to use fewer resources.

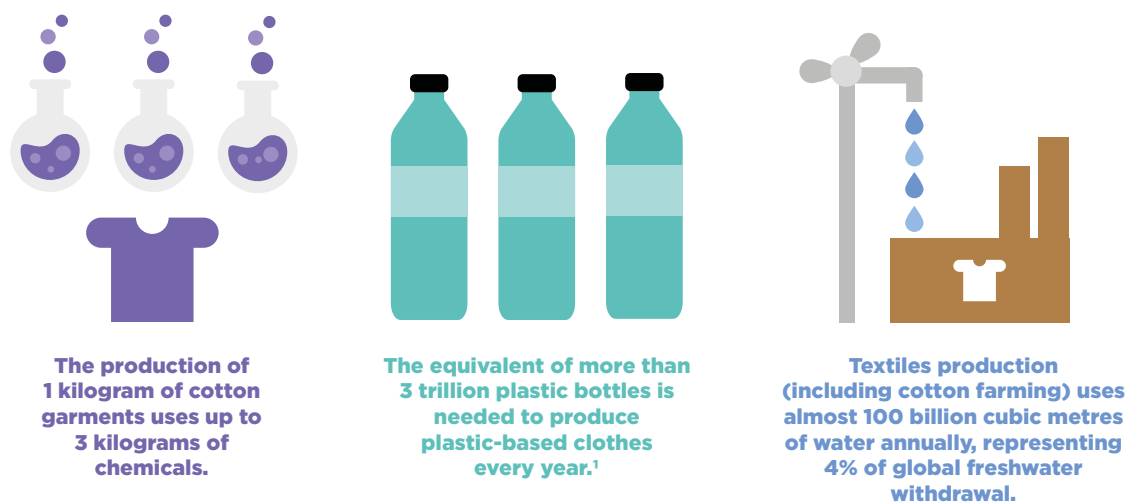
4.1. Textiles production methods are resource-intensive and challenges exist to adopt innovations

The materials currently used in textiles production have been selected for their specific functionality and optimised for cost; however, they have significant drawbacks in terms of resource use. This is particularly true for the two dominant materials: polyester and cotton. Polyester production uses large amounts of resources and energy, and cotton farming requires high volumes of fertilisers and pesticides (unless farmed organically), as well as significant amounts of water. Additionally, current processing methods are also resource-

hungry and highly inefficient (see Figure 18).

For example, the production of 1 kilogram of cotton garments uses up to 3 kilograms of chemicals,⁴⁹⁴ while up to 200,000 tonnes of dyes worth USD 1 billion are lost to effluents every year due to inefficiencies in the dyeing and finishing processes.⁴⁹⁵ Textiles production is also highly GHG intensive, as the production of 1 kilogram of textiles emits 20 kilograms of CO₂ equivalent, whereas for the same amount of plastic and paper, 4 kilograms and less than 1 kilogram of CO₂ equivalent are produced, respectively.⁴⁹⁶ To put this into perspective, in 2015, polyester production for textiles alone was responsible for over 700 million tonnes of CO₂ equivalent.⁴⁹⁷ Additionally, up to 4,300 litres of water are used to produce 1 kilogram of cotton fibres, although this varies depending on climatic conditions. Dyeing and finishing can use around 125 litres of water per kilogram of cotton fibres.⁴⁹⁸

FIGURE 18: THE TEXTILES INDUSTRY USES SIGNIFICANT AMOUNTS OF RESOURCES



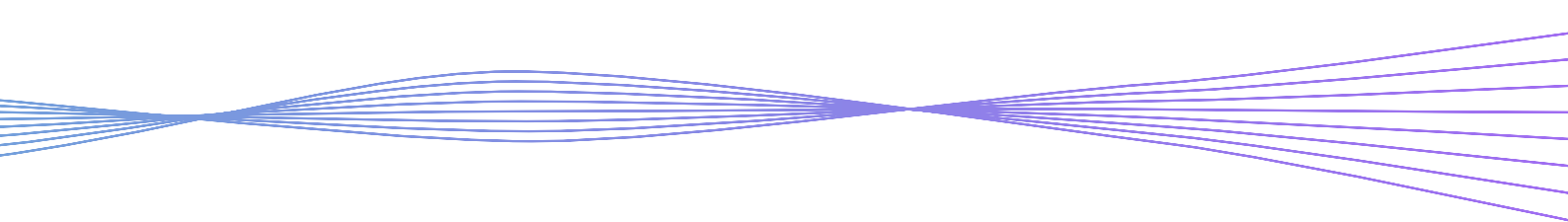
1 Based on an average weight of 10 gram of a 0.5 litres PET bottle

Source: KEMI, *Chemicals in textiles: Risks to human health and the environment* (2014), p.33; World Bank, AQUASTAT, and FAO, *Dataset: Annual freshwater withdrawals, total* (2014); Circular Fibres Initiative analysis



Resource price and supply risks pose a threat to profitability. A business-as-usual approach to such resource use will present a long-term risk to business profitability. The price of oil has been historically volatile, exposing businesses to unexpected input cost spikes for polyester and other plastic-based fibres.⁴⁹⁹ The industry's generally resource-hungry approach creates other problems as well. For example, at present,

many of the key cotton-producing countries are under high water stress, including China, India, the US, Pakistan, Turkey, and Brazil. Water management and other environmental conditions have significant impacts on the availability of cotton, and therefore lead to price fluctuations. This was seen in 2011, when cotton prices rose by over 30% in less than a month due to flooding in Australia, Pakistan, and



China.⁵⁰⁰ Increasing the proportion of recycled or renewable alternatives could help businesses spread the risk of sudden price shocks in raw materials.

Technologies and innovation to reduce resource use face challenges to adoption.


The textiles value chain is highly complex, and characterised by significant degrees of fragmentation and intricate relationships between suppliers and retailers. The top 20 apparel retailers account for 15% of the global retail value.⁵⁰¹ By comparison, the top 15 global supermarket companies account for more than 30% of world supermarket sales.⁵⁰² This dynamic is consistent across apparel manufacturers and suppliers as well as across regions. Consequently, large retailers typically have hundreds of suppliers, spanning many countries.⁵⁰³

While there are many entrepreneurs and innovators offering promising solutions to reduce resource use or to find alternative materials that reduce waste, they are small and face challenges to being adopted at scale. Similarly, manufacturing and processing technologies for apparel have not seen widespread adoption of improvement measures, even where technologies exist and offer the opportunity to use resources more efficiently. Examples include small, easily implementable solutions to avoid waste and capture cost savings – for example energy-efficient lighting systems for factories or treatment systems to capture and reuse water in production facilities – as well as more complex solutions transforming entire processes. There are few incentives for suppliers to invest in these technologies or to improve production methods, as this requires significant upfront capital investment. Decisions are often made from a short-term and cost-optimisation perspective, due to squeezed profit margins and the lack of long-standing relationships between buyers and suppliers.

Recycled materials are also available for textiles production, and have the potential to reduce the input of non-renewable resources, yet they, too, suffer challenges for large-scale adoption, including issues with quality and a lack of cost-competitiveness (Ambition 3).

Cross-value chain collaboration is needed for innovation to reach scale. To overcome the high degree of fragmentation in the whole value chain, brands and retailers need

to collaborate with the people who are producing their clothing. Partnerships and shared investment opportunities between innovators, brands, and manufacturers could identify and scale promising solutions that would bring them to the mainstream market. Brands can drive and support innovation in new technologies and materials through investment. Currently, many brands and retailers are not allocating considerable budgets for research into technologies and materials. Brands do dedicate R&D expenditure to design and trend research,⁵⁰⁴ yet less so into production technology. Innovation can be particularly impactful in two areas: novel materials that avoid the drawbacks of the current materials palette, and processes using fewer resources. Increased transparency and information-sharing through open-source platforms offers a route towards rapid adoption of innovation and improved processes by sharing best practice examples between a brand or retailer's suppliers. This should be augmented by building trust through longer-term relationships and potentially co-investing in technologies that improve output performance.



4.2. Account for the costs of negative externalities to incentivise good system-level resource management

Brands that understand the impacts of sourcing decisions will be better informed to demand improved processes and materials from their supply chains. This can be made more transparent by accounting for the cost of externalities of supply, such as pollution or health impacts on workers.

A report by the Global Leadership Award in Sustainable Apparel (GLASA) states that resources and services from natural systems are not adequately priced by market economics, and as they are not financially valued, there is no market incentive to manage them.⁵⁰⁵ For example, it has been estimated that if the true cost of conventional cotton cultivation in India

accounted for negative environmental and societal externalities, it would equate to EUR 3.65 (USD 4.28) per kilogram – around seven times the actual market price.⁵⁰⁶

Examples exist already in the industry that show how these measures can be successful. Puma, part of the Kering Group, has driven efforts to increase transparency in their production process, and was the first brand to introduce an Environmental Profit and Loss (EPL) methodology in 2011. The EPL recognises that Puma's core business depends on a variety of resources and values these services, as well as the impacts of their business activities on natural systems, by using a monetary value across the supply chain. Following successful implementation at Puma, Kering has adopted the EPL at group level.⁵⁰⁷ Benefits reported by Kering include better understanding of the risks and opportunities for raw materials, better relationships with suppliers as they work together to manage environmental challenges, and building greater trust with stakeholders through increased transparency. In 2015, Kering reported a reduction in carbon emissions, supply-chain waste, and water consumption, of 11%, 16%, and 19% respectively since its 2012 EPL. These savings are driven by greater transparency in the supply chain, allowing the company to avoid high-impact sources, coupled with changes in product design and material choices.⁵⁰⁸ Kering has made the methodology open-source, offering a tangible way to build collaboration at scale and acknowledging the power of such actions being driven by all retailers that use shared supply chains.⁵⁰⁹

The Natural Capital Protocol is a framework that builds on existing techniques to identify, measure, and value natural capital in the context of business decisions.⁵¹⁰ Created by the Natural Capital Coalition – a global multi-stakeholder collaboration bringing together over 200 global initiatives and organisations – the protocol acknowledges that natural capital impacts are often specific to the sector in which a business operates, and has developed an apparel sector guide, providing more specific guidance on how to apply the protocol in the textiles industry.⁵¹¹

Tools such as the Sustainable Apparel Coalition's Higg Index, or Made-By's Environmental Benchmark for fibres can also provide a first step for the entire textiles value chain to understand the wider impacts of production.⁵¹² These tools could also gather information

from all industry efforts in one place. Brands and manufacturers could use this to support sourcing decisions and to create transparency on the impacts across their entire supply chain. Once the true value of production is measured and understood, the textiles supply chain would be able to work collaboratively to find solutions to better manage resources.

4.3. Find sources for renewable feedstock where resource input is needed

Even with an increased use of recycled materials (Ambition 3), some virgin material input will likely always be required. Where such input is needed and no recycled materials are available, it should increasingly come from renewable resources. This means using renewable feedstock for plastic-based fibres and using regenerative agriculture for cotton and other cellulose-based fibres. Innovation could also lead to the introduction of completely new materials that avoid the use of large amounts of non-renewable resources.

4.3.1. MOVE TO RENEWABLE FEEDSTOCK FOR PLASTIC-BASED FIBRES

Bio-based or CO₂-based feedstocks could offer a solution for avoiding fossil fuel inputs for plastic-based fibres. Plastics can be made from biomass sources including plants, such as sugar cane or corn, or from waste materials, such as waste vegetable oil, or from algae.⁵¹³ Biomass feedstocks that create biodegradable plastics could potentially also offer a solution to plastic microfibre release into the environment.

4.3.2. MOVE TO REGENERATIVE FARMING METHODS FOR COTTON AND OTHER CELLULOSE-BASED FIBRES

In cotton production, non-renewable resource inputs can be reduced by introducing regenerative agricultural practices, which do not use synthetic pesticides or fertilisers (see Section 1.1.4).

As well as avoiding the resource inputs and downsides of synthetic pesticides and fertilisers, regenerative farming practices avoid other negative impacts on natural systems. Viscose, and similar cellulose-based fibres, are mainly made from wood, sometimes contributing to the deforestation of ancient and endangered forests or leading to the loss of habitats. The Rainforest Action Network estimates that 120 million trees are logged every year to make clothing,⁵¹⁴ an area expected to increase since the production of dissolving pulp – the base material for viscose and similar fibres – could double by 2050.⁵¹⁵ Regenerative methods of sourcing cellulose include seeking out fast-growing plant species that do not need prime agricultural land, and can be farmed in a way that makes them part of a thriving ecosystem.

4.3.3. INNOVATE NEW MATERIALS SUITABLE FOR A CIRCULAR SYSTEM

While seeking solutions to the existing challenges of today's material mix, driving innovation in new materials would aid discovery of those fit for a circular system more rapidly. Interesting, yet small-scale, alternatives are emerging from using waste products, such as innovator Orange Fiber, which uses waste from orange juice production to make cellulose-based fibres.⁵¹⁶ Similarly, QMILK uses leftovers from dairy production,⁵¹⁷ AgraLoop uses agricultural waste to create cellulose-based fibres,⁵¹⁸ and EcoAlf turns used coffee grounds into fibres.⁵¹⁹ Other explorations into new fibres include artificial silk fibres, such as Biosteel or Bolt Threads, or fibres produced from algae, such as AlgaeFabrics.⁵²⁰ While some such innovations are still in research and development or at lab scale, Italian high-fashion brand Salvatore Ferragamo has already employed Orange Fiber in one of its collections.⁵²¹ Luxury brand Stella McCartney has developed two demonstration outfits made from Bolt Threads' artificial silk, and expects to start selling clothing containing the innovative material in the next couple of years.⁵²² However, further exploration is needed to understand if, or which, other such fibres could be advantageous compared to those dominating the system today, and how they could be scaled to industrial levels.

Such efforts require a common innovation agenda, with a clear vision and guidelines on the

direction for materials in a circular system. This needs to be guided by brands, in collaboration with designers and material innovators, to align with their material specifications. Accelerator programmes like Fashion for Good could help coordinate these efforts, and connect brands to small innovators.⁵²³

4.4. Remove barriers to adopting more efficient textiles production methods at scale

Brands and retailers have a significant opportunity to work collaboratively with their suppliers to implement best practices. Examples of reducing energy use, water use, and offcut waste already exist across the industry. However, there are barriers to adopting them more widely, including low awareness of best practices, a lack of technical skills to implement them, misaligned incentives in current pricing schemes, and difficulties in funding investments. Making information on viable improvements more easily available, as well as closer cooperation between brands and manufacturers – including long-term commitments towards improved resource use – could help overcome these barriers.

Business cases exist for more efficient production methods

Significant opportunities exist to reduce the waste generated during the production of garments in the form of offcuts of materials. Most sources – including those used for the material flow analysis carried out for this report – estimate the waste in clothing manufacturing at between 10% and 20% of the materials used.⁵²⁴ However, recent field research analysing waste from seven garment factories concluded that, on average, 25% of material is cut off during production,⁵²⁵ and that this figure can be 40% or more in some cases.⁵²⁶ Methods are being developed to reduce the offcuts through direct reuse in the production process. An example of such a method is provided by Reverse Resources, which has developed

software that allows manufacturers to analyse and then reduce their offcuts (see Case Study C). Analysis of such solutions suggests that a positive business case exists for both

manufacturers and buyers, though collaboration between the two is needed to overcome currently misaligned incentives.⁵²⁷

CASE STUDY C: REVERSE RESOURCES

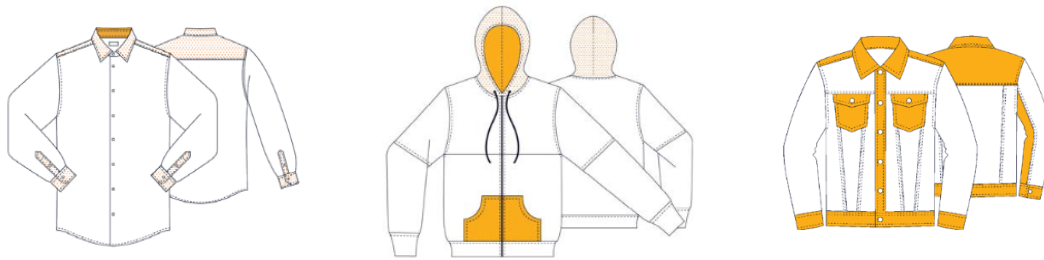


Image source: Reverse Resources

Reverse Resources provides software to manufacturers and their buyers to work together on making profitable use of factory offcuts. The software measures the quantity of production offcuts, maps them by type, and allows the manufacturer to share relevant data with buyers.⁵²⁸

Reverse Resources has developed three approaches to using offcuts in mass production:

- Using offcuts invisibly on internal sections of a garment (e.g. pockets, cuff facings or the insides of shirt collars). This allows the exterior appearance of the garment to remain unchanged.
- Using offcuts for small details on the outside of a garment, in the same colour as the rest of the garment or a contrasting colour. In this case, the piece of fabric is visible, but does not significantly affect the design.
- Using offcuts for portions of other garments, which are specifically designed with a certain stream of offcuts in mind. This can increase their application in mass production and reduce design limitations.⁵²⁹ This approach does not directly reduce the waste in the production of one garment but uses the offcuts in the production of others, and is therefore a very effective way of fabric recycling (see Box J, p.95).

These approaches could use more than 20% of offcuts, which is equivalent to 3% of all virgin fabrics.⁵³⁰ For offcuts that cannot be used in these ways, the software provides information of use to recyclers, with the aim of helping them pursue higher-value types of recycling.⁵³¹

Business cases also exist for the reduction of energy and water use in production processes. This is particularly true as volatile energy prices and increasing environmental and regulatory pressures present a favourable context to shift towards more resource-efficient and renewable-based production in order to increase cost-competitiveness.⁵³² Many manufacturers and retailers are already making efforts to reduce energy and water use in production

technologies, and examples show that individual measures can already result in significant cost savings. The National Resource Defence Council has identified ten best practices for water and energy saving in textile mills that have low investment costs and payback periods of around one year. The measures include detecting and repairing leaks in water or steam systems, insulating equipment such as dye baths, and recovering heat and water for reuse.⁵³³ Case

studies conducted by the Georgia Technical Institute on air-jet weaving machines found that reducing air leakage from 12% to 6% resulted in an expected electricity cost saving of USD 440,000 each year for a system operating 500 weaving machines.⁵³⁴ Likewise, better water

management can deliver cost and productivity improvements and reduce risks to continued operations.⁵³⁵ One example of a company succeeding with implementing energy efficiency is Viyellatex (see Case Study D).

CASE STUDY D: VIYELLATEX

Viyellatex is a vertically-integrated garment manufacturer based in Dhaka, operating along several steps of the value chain from spinning to garment production. The company - which supplies brands such as Calvin Klein, Puma, Esprit, and Hugo Boss - had an annual turnover close to USD 200 million in 2011 and employed around 17,000 people.⁵³⁶ It has received numerous awards for its sustainability focus. These initiatives are driven by a clear business case and result in economic and environmental benefits as well as positive publicity and an enhanced reputation with its suppliers and customers.⁵³⁷

The Chairman and CEO K. M. Rezaul Hasanat explains the company's rationale for implementing the initiatives: "We can be environmentally friendly but, unless there is a return, we can't continue the initiative. We are saving money".⁵³⁸ An estimated 35% of energy savings were achieved through various initiatives, translating into an economic benefit of total Bangladeshi Taka (BDT) 27 million (USD 400,000) in 2010.⁵³⁹

Energy savings come from utilising output wastage of steam in heat boilers, recycling heat from dyeing units, using cooling pads as alternatives to air conditioning, as well as employing energy-efficient light bulbs and sewing machines with energy-efficient motors. Using the output wastage of steam alone achieved 40% savings compared to the original heating costs. Water savings included reuse of treated effluent water for toilet flushes, using rainwater from roof collection for production, and employing wastewater treatment.

All these efforts culminated in the construction of two new factories in 2011 and 2012, both certified by the US Green Building Council. Both buildings incorporate efficiency measures, such as a rainwater harvesting system, skylight ceilings, and solar panels. For the second factory, known as 'Eco-Fab', the reported ambition is to provide 30% of the energy requirements through renewable sources. The aggregate investment in the projects is estimated at around USD 5 million.⁵⁴⁰

4.4.1. MAKE VIABLE IMPROVEMENTS IN PRODUCTION PROCESSES READILY AVAILABLE TO ALL GARMENT AND TEXTILE MANUFACTURERS

Making best-practice cases available, and including clear guidelines on implementation, would allow small manufacturers to benefit from cost savings and enable them to reduce their resource use. Most textile plants are small enterprises and operate on limited budgets and personnel. Small and medium-sized companies (SMEs) throughout the value chain can find it difficult to access the latest knowledge on easy-to-achieve energy and water-saving measures. This means that often even small improvement

measures are not implemented due to lack of awareness, lack of funding, or limited technical knowledge.⁵⁴¹ Knowledge could be made more readily available through the use of an online toolbox or platform, such as the Euratex 'Energy Made-To-Measure' platform, which gathers best-practice examples and makes these available for free, particularly with the aim of supporting SMEs to increase their energy efficiency.⁵⁴² Coordination is critical to avoid duplication or fragmentation and counter-productive multiplication of platforms.

4.4.2. MOVE TO JOINT INVESTMENTS AND LONG-TERM COLLABORATION BETWEEN RETAILERS AND MANUFACTURERS

Brands that work with suppliers to implement process improvements will build trust and better transparency on production processes. Despite potential long-term benefits, technological improvements often require high upfront costs and involve long payback periods, which are seen as too lengthy by some small manufacturers – particularly without guaranteed purchases in the future. According to Charles Ardent-Clarke of the United Nation’s Environment Programme (UNEP): “Often the paybacks involved in energy- or water-efficient technologies can be three to four years. However, anything over six-month payback is too much for many manufacturers due to financial constraints”. Even though there can be long-term payback on investment in better processes, Mauro Scalia from Euratex highlights the need for buyers and suppliers to work together on process improvements because these “can be difficult for a manufacturer with revenues of under EUR 50 million [USD 59 million] to undertake alone, without the help of their customers”. Building a collection of trusted suppliers can promote long-lasting relationships that offer the opportunity to

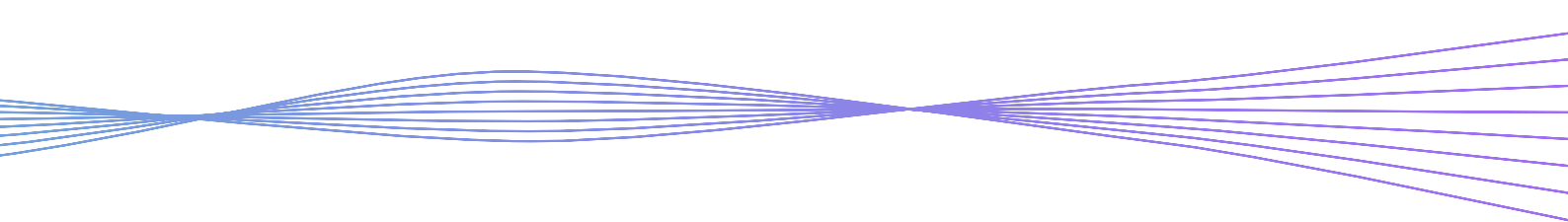
increase the consistency of quality while sharing the associated risks of investments.

Brands and retailers could leverage their scale to invest in measures that improve resource use on a large scale through long-term commitments. They could also work with their suppliers to implement change and overcome barriers of implementation. In the long run, this would benefit all parties, in the form of better margins from energy efficiency and reduced reliance on non-renewable resources. This collaboration is needed, as manufacturers hindered by a lack of knowledge, financial barriers, or low awareness of the alternatives available will struggle to create change in the production processes alone. According to the CEO of a Bangladeshi manufacturer: “If the retailers want something, they have the power at the end of the day. Whatever a manufacturer does, it needs to fit together with what the customer wants”. Some brands are already implementing measures together with their supplier base. For example, Nike has launched a joint programme with its suppliers to implement best practices and technologies along their supply chain (see Case Study E). A European retailer gives the following perspective: “Large brands have the kind of leverage small manufacturers and retailers can only dream of. If the change starts somewhere, it should be from there as they have the power and the cash needed to support these changes”.

CASE STUDY E: NIKE’S ‘REWIRE’

Nike’s ‘Rewire’ approach is a supply-chain strategy based on “integration, incentives, and innovation”.⁵⁴³ One of the aims of the programme is to incentivise suppliers to become more efficient and innovative. To this end, Nike trains and encourages its suppliers to create innovative solutions that improve productivity.

To be able to measure progress, Nike has introduced the Manufacturing Index (MI) across its supply chain. Contracted factories are measured on sustainability performance – in addition to the traditional business metrics of quality, timely delivery, and cost.⁵⁴⁴ To measure sustainability, Nike created a Sustainable Manufacturing and Sourcing Index, assessing environmental, health, safety, and labour practices, and performance, on a scale of red, yellow, bronze, silver, and gold. By 2015, 86% of suppliers were rated bronze or better.⁵⁴⁵ High-performing suppliers get access to training in key areas to further improve their performance, including waste management, energy and water efficiency, and implementation of lean practices.⁵⁴⁶ This ‘pull’ model incentivises suppliers to strive for the highest performance instead of just complying with minimum standards. This also helps to create a generally more positive mindset towards improvements and efficiencies.



4.5. Innovate processes to use fewer resources

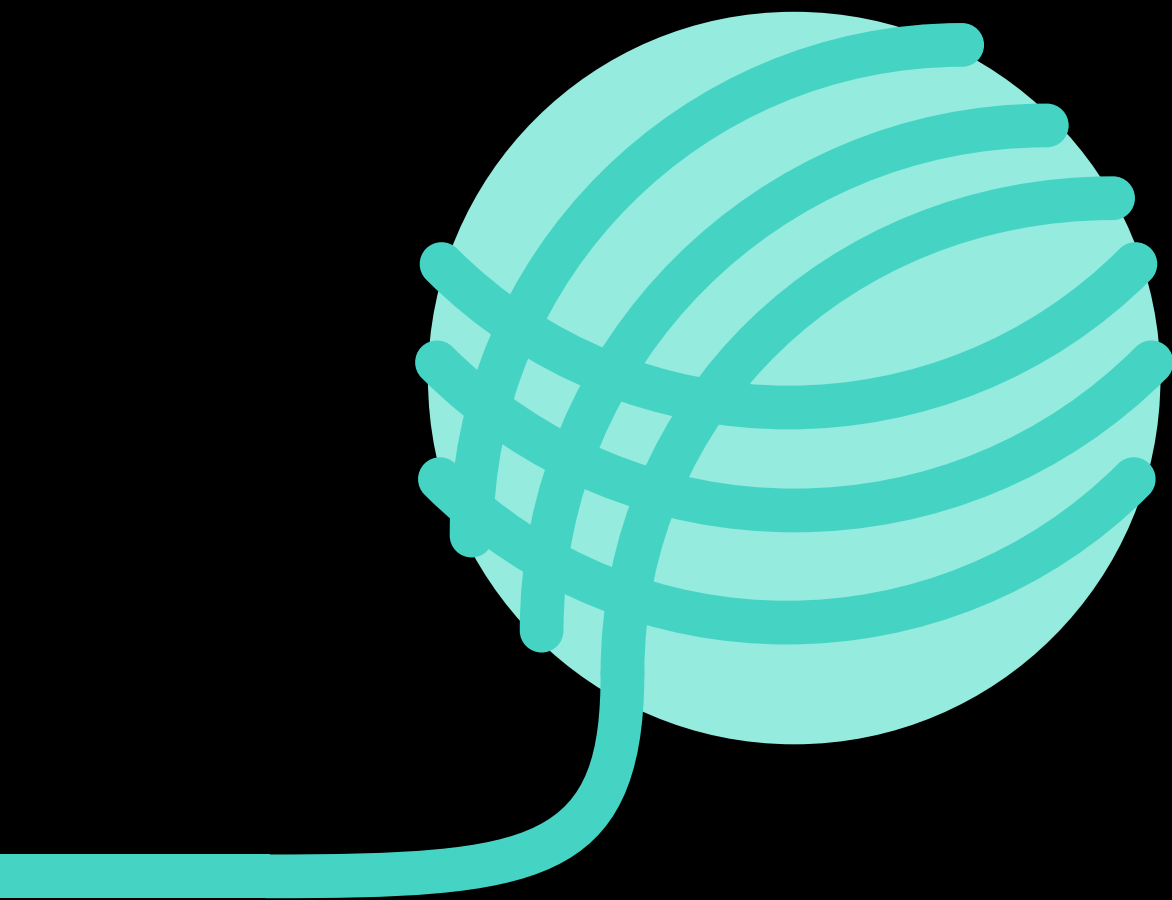
Innovation in production processes could capture value by finding alternatives to conventional chemical use, and also reduce energy use, water use, and waste.

As discussed earlier, the materials currently used in the apparel industry require large inputs of non-renewable materials in the form of fertilisers, pesticides, dyes, and other process chemicals. In many cases these chemicals are not retained in the process, leading to chemical waste and pollution incidents. Examples of successful innovation in production processes include the improved production of cellulose-based fibres. The traditional viscose process uses large amounts of solvents to extract the cellulose and transform it into fibres that can be spun into yarn. These solvents are hazardous, and without proper treatment are lost during processing in factory effluents.⁵⁴⁷ The Lyocell process – in contrast – can recover up to 99.5%⁵⁴⁸ of the solvent and reuse it. The fibres emerging from both processes possess slightly different properties, but the overall resource inputs, as well as leakage of chemicals, are significantly reduced.

Water can also be reduced through process improvements during production and processing. Water-saving practices in cotton-growing include avoiding areas where irrigation is needed and moving to rain-fed production or, where irrigation is used, shifting from furrow to drip-fed irrigation – the latter has been shown to

achieve a 20% reduction in water use.⁵⁴⁹ Dyeing and finishing processes require heavy use of water, for example to dissolve dyes or wash fabrics afterwards. Mechanisation and water-reuse technologies offer a first step to reducing water use in the dyeing process.⁵⁵⁰ Innovation towards low or zero water-use processes for dyeing are emerging. Due to the need for water use during dyeing, such processes can have impacts on energy or chemical reduction, too. For cotton, ColorZen offers pre-treatment that modifies the chemical structure of cotton to make it more receptive to dye without the discharge of hazardous substances and claims to reduce water use by 95%, and energy use by 75%, compared to conventional cotton treatment.⁵⁵¹

Another innovator, DyeCoo has developed a disruptive technology called Drydye that does not use any water and significantly reduces solvent use in the dyeing process, by using compressed carbon dioxide as a solvent in a closed-loop system. Using this technique, 95% of the carbon dioxide can be recovered and reused, and while the capital investment in the equipment is higher than for conventional dyeing, it can reduce operating costs by 45%, due to energy savings of 50%.⁵⁵² Currently, the Drydye technology can only be used on plastic-based fibres, but dyes suitable for cotton are being investigated. While the current high capital cost of installing the technology remains a barrier to large-scale adoption, some brands, such as Adidas and Nike, have started to integrate waterless dyes into their collection.⁵⁵³ This increased uptake by major players will help to bring costs down and make such advances accessible to a larger number of manufacturers.



APPENDIX A. OVERVIEW OF COMMON TEXTILE MATERIALS

Today's textiles system is dominated by, and optimised for, cotton and polyester.

Cotton has historically been the dominant material used for textiles production, yet over the last few decades it has lost market share, mainly to plastic-based fibres such as polyester.⁵⁵⁴ Currently, polyester makes up 55% of total textiles fibre production and cotton 27%.⁵⁵⁵

The materials used today to make textiles come with a variety of material-specific advantages and disadvantages. To fully understand the impact of the different materials used, it is necessary to look at all phases, from feedstock for raw materials through production methods, during use, and after use. While further efforts are needed across the industry to build a comprehensive picture of all impacts of the common materials used – and potential alternatives – the major advantages and disadvantages of a range of materials are discussed below.

This highlights the need for innovation to improve the existing fibres to avoid negative impacts for people and the environment, or to investigate and rethink the materials needed for a circular system and to create new fibres with no negative impact at all.

A.1. Plastic-based fibres

Plastic-based fibres – often called synthetic fibres – are usually produced from oil and account for two-thirds of the material input for textiles production.⁵⁵⁶ The most common materials are polyester (55%), followed by nylon (5%), and acrylic (2%).⁵⁵⁷ Elastane is less prominent in terms of volume but is used in many garments in small quantities. All plastic-based fibres share the following advantages and disadvantages.

Advantages: Plastic-based fibres do not require agricultural land and use little water in production and processing. They are versatile and dry quickly after washing.

Disadvantages: Plastic-based fibres use large quantities of non-renewable feedstocks, and are energy-intensive to produce.⁵⁵⁸ During use, textiles made from plastic-based fibres shed plastic microfibres when washed that can end up in the environment or the ocean. Plastic-based fibres are not biodegradable and therefore remain in the environment for a long time.⁵⁵⁹

Polyester

Polyester – the most common textile fibre overall – is used in all kinds of textiles, particularly sportswear and womenswear.⁵⁶⁰

Additional advantages: Polyester is relatively strong, crease-resistant, soft, and has a good drape.⁵⁶¹ Compared to other mainstream materials, polyester is cheap. The process for dyeing polyester requires fewer chemicals than for cotton.⁵⁶² During use, it has low energy requirements for care, as it is crease-resistant and dries quickly. Through chemical recycling, polyester can be restored to virgin quality.⁵⁶³

Additional disadvantages: The production of polyester often uses heavy metals as a catalyst, specifically antimony, which is a known carcinogen if inhaled.⁵⁶⁴ It is particularly energy-intensive, especially during dyeing, which requires high temperatures.⁵⁶⁵

Nylon

Nylon is used to make a variety of garments including shirts, dresses, underwear, raincoats, hosiery, socks, and sportswear.⁵⁶⁶

Additional advantages: Nylon is strong, elastic, wrinkle-resistant, and has higher moisture regain than polyester and good drape. Nylon 6 can be profitably recycled on an industrial scale using de/repolymerisation.⁵⁶⁷

Additional disadvantages: Producing nylon emits nitrous oxide, a potent greenhouse gas.⁵⁶⁸ Even compared to other plastic-based fibres, it is very energy-intensive to produce.⁵⁶⁹

Acrylic

Acrylic is commonly used in jumpers, fleece, and sportswear.⁵⁷⁰

Additional advantages: Acrylic possesses wool-like properties – it has good drape and provides warmth – though it is much cheaper to produce than wool and dries more quickly.⁵⁷¹

Additional disadvantages: Even compared to other plastic-based fibres, it is very energy and chemical-intensive to produce.⁵⁷²

Elastane

Elastane – also known as spandex – is blended with other fibres to produce textiles that need additional stretch – mainly underwear, jeans, shirts, swimwear, and sportswear.⁵⁷³

Additional advantages: Elastane can stretch up to six times its normal length and recover to almost its original length immediately.⁵⁷⁴ Adding elastane also increases the comfort and crease-resistance of clothing.⁵⁷⁵

Additional disadvantages: Adding elastane to fabric made from other fibres prevents pure material streams, making recycling more difficult. As elastane is typically used in quantities of less than 3% by weight in clothing,⁵⁷⁶ it is difficult to find economic ways to recycle this small portion, even if it can be filtered out.

A.2. Cellulose-based fibres

Cellulose-based fibres refers to those obtained from plant-based material. This material can be either directly captured from plants, such as cotton, or treated chemically to extract and process cellulose. Cellulose-based fibres account for one-third of all fibres used for textiles, 27% of which is cotton alone.⁵⁷⁷ If produced without using or retaining any substances of concern, cellulose-based fibres can be safely biodegraded.

Cotton

Cotton is used widely in clothing, particularly for T-shirts, jeans, and underwear.⁵⁷⁸

Advantages: Cotton is lightweight yet strong, very absorbent, non-allergenic, and offers good drape.⁵⁷⁹ Cotton can be recycled mechanically without additional chemical use if supplemented with virgin material. It is also possible to chemically recycle cotton into lyocell or viscose due to its high cellulose content.

Disadvantages: Cotton growing and processing requires large amounts of water, which is especially problematic in water-scarce regions, and usually large amounts of pesticides and fertilisers are used.⁵⁸⁰ It does not absorb dyes well and is therefore treated heavily with chemicals in the dyeing process.⁵⁸¹ Cotton creases easily and chemicals must be used or cotton blended with other materials if crease-resistance is required.⁵⁸² Energy usage is high for cotton-spinning.⁵⁷⁷

Viscose

Viscose – also known as rayon – is made by extracting cellulose from wood using solvents.⁵⁸⁴ Viscose is used for shirts, dresses, and nightwear.⁵⁸⁵

Advantages: Viscose is soft, and has a similar drape to silk (while being considerably cheaper).⁵⁸⁶

Disadvantages: The production solvent used to produce viscose fibres (carbon disulphide) is highly toxic and recovery of the solvent is typically very low, so the process constantly requires new inputs.⁵⁸⁷ Unsafe release of solvents in wastewater can have hazardous impacts, and high-profile pollution incidents have been reported.⁵⁸⁸ However, newer production methods allow very efficient chemical reuse and recover up to 90% of the solvent.⁵⁸⁹ Typical dyeing and finishing processes additionally require high use of water, energy, and chemicals.⁵⁹⁰ Furthermore, there is a risk to the environment where wood is sourced illegally, for example, from ancient rainforests.⁵⁹¹

Lyocell

Lyocell can be made from wood, cotton scraps, and other sources of cellulose, and is used to make dresses, blouses, jeans, and shirts.⁵⁹²

Advantages: Lyocell is soft and strong.⁵⁹³ The production solvents used are non-toxic and can be kept in a closed-loop process,⁵⁹⁴ with

one manufacturer reporting the ability to retain almost 100% of process solvents.⁵⁹⁵

Disadvantages: Lyocell production processes are highly energy-intensive and textiles made from lyocell tend to crease easily.⁵⁹⁶

Bast fibres (linen, hemp, jute)

Bast fibres include flax, hemp, and jute. They are often used for shirts, dresses, and trousers, worn in warmer temperatures.⁵⁹⁷

Advantages: Bast fibres dry quickly, are durable, absorbent, and soften as they are washed.⁵⁹⁸ They require small quantities of water and fertiliser to grow, and can grow on land unsuitable for food production.⁵⁹⁹

Disadvantages: Bast fibres are relatively costly and the spinning is energy-intensive. The fibres extracted from hemp tend to be coarse and abrasive, so clothing produced from them tends not to drape well and this can limit their use.⁶⁰⁰ The cultivation of hemp fibres is banned in many countries due to the narcotic properties of the plant, *Cannabis sativa*, even though hemp used for fibre production contains very low quantities of the chemical with narcotic properties.⁶⁰¹

A.3. Protein-based fibres

Protein-based fibres refers to those from animal sources, such as wool and silk. They account for less than 2% of all fibres used, the vast majority of this being wool.⁶⁰² If produced without using, or retaining any substances of concern, protein-based fibres can be safely biodegraded.

Wool

Wool – that is animal hair, most often from sheep – is used to make rugs, blankets, jackets, knitwear, and suits.⁶⁰³

Advantages: Wool is warm and breathable, it easily takes up dyes, which decreases the amount needed, has great moisture-wicking abilities, and is highly durable. Some types of wool can be obtained as a secondary product of meat production.⁶⁰⁴ Wool needs less washing than most other fibres. Wool fibres are relatively long, making them more suitable for mechanical recycling, for which there are established systems already in place.⁶⁰⁵

Disadvantages: Wool is comparably expensive. It requires significant amounts of land to produce and sheep release large amounts of methane – a potent greenhouse gas.⁶⁰⁶ Wool must be treated to remove dirt and pests before use, which often uses chemical treatments that can have negative impacts on the environment if poorly managed or simply discharged.⁶⁰⁷ Bleaching agents are sometimes used to whiten wool, which results in wastewater containing substances of concern that need to be disposed of to avoid these leaking into the environment.⁶⁰⁸

Silk

Silk is commonly used to make dresses, blouses, and scarves.⁶⁰⁹

Advantages: Silk takes dyes well. It has a soft feel, and retains its shape well. Silk feels cool in the summer and provides warmth in the winter, and can absorb significant amounts of moisture before feeling wet.⁶¹⁰

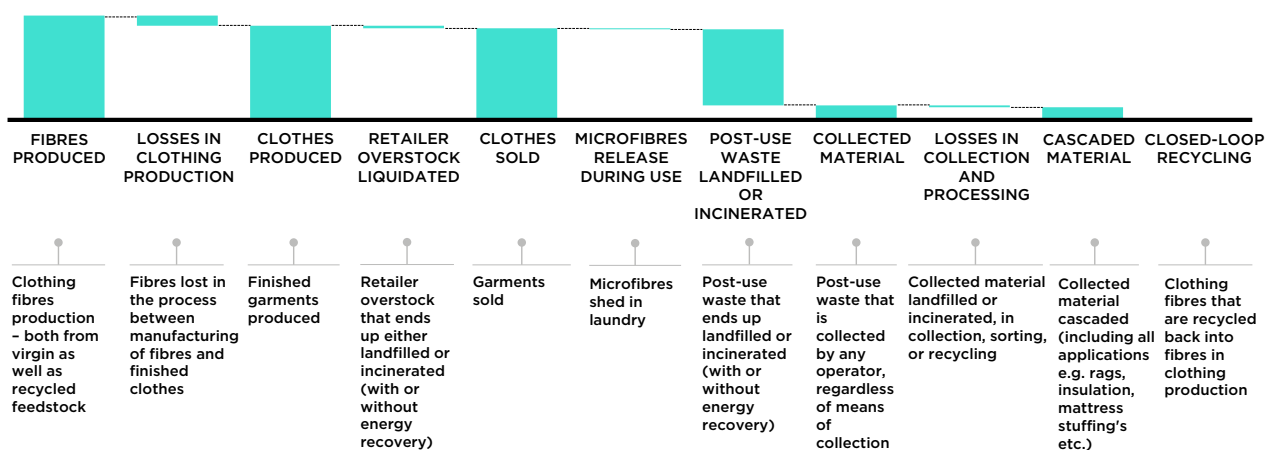
Disadvantages: Silk is expensive due to its labour-intensive production process.⁶¹¹ Silk worms need to be fed a special diet of mulberry leaves.⁶¹² The majority of silk produced comes from the *Bombyx mori* silkworm, which is harvested by steaming to kill the silk moth and extract the filament, because if the moth is left to emerge it would damage the filament.⁶¹³

APPENDIX B. METHODOLOGY OVERVIEW

Appendix B.1. Global material flows analysis

This analysis of the global material flows of textile fibres is based on an aggregation of fragmented data sets, often with varying definitions and scope. The analysis not only reveals a significant opportunity to increase circularity and capture material value, but also highlights the need for better reporting standards, transparency, and consolidation on a global level.

DEFINITIONS FOR OVERVIEW OF GLOBAL MATERIAL FLOWS FOR CLOTHING



ASSUMPTIONS ON GLOBAL MATERIAL FLOWS FOR CLOTHING

	METRIC	VALUE	UNIT	COMMENT	SOURCE
FIBRE PRODUCTION	Cotton production for clothing	13	million tonnes	Calculated, see below	
	+				
	Plastic-based production for clothing	33	million tonnes	Calculated, see below	
	/				
	(1 - % of other fibres)	12	%	Share of other fibres (not plastic-based, not cotton) of total fibre production, 2014	Gherzi
	=				
	Total fibre production for clothing	53	million tonnes		
COTTON	Total cotton production	20	million tonnes	Total cotton production - figures for 2014 used to better reflect long-run average	USDA
	x				
	Share of cotton production going to clothing production	67	%	% of cotton in clothing production (2011-2015) based on extrapolation in share change between 2007-2010, applied on baseline of 2010 figures – average over 5 years used in calculations	FAO, Assumptions
	=				
	Cotton production for clothing	13	million tonnes		

PLASTIC-BASED FIBRES	Total plastic-based fibres production	50	million tonnes	Total plastic-based fibres production	IHS FAO, Assumptions
	x				
	Share of plastic-based fibres going to clothing production	67	%	% of plastic-based fibres in clothing production (2011-2015) based on extrapolation in share change between 2007-2010, applied on baseline of 2010 figures - average over 5 years used in calculations	
	=				
	Plastic-based fibres production for clothing	33	million tonnes		
OTHERS	Total fibre production for clothing	53	million tonnes		Gherzi
	x				
	Share of other fibres in total fibre production	12	%	Share of other fibres (not plastic-based, not cotton) of total fibre production, 2014	
	=				
	Total other fibres in clothing production	6	million tonnes		
FABRIC PRODUCTION	Total fibre production for clothing	53	million tonnes		Gherzi
	x				
	(1 - % loss between fibre and yarn)	3	%	Loss of material between fibre and yarn ¹	
	=				
	Total textile production for clothing	51	million tonnes		
GARMENT PRODUCTION	Total textile production for clothing	51	million tonnes		Gherzi
	x				
	(1 - % loss between textile and garment production)	6	%	Loss of material between textiles and finishing and garmenting	
	=				
	Garment production	48	million tonnes		
SALES VOLUME	Garment production	48	million tonnes	Total amount of garments produced each year around the world	Calculation, Assumption
	=				
	Consumption volume ²	48	million tonnes	Clothes bought in one given year assumed to equal to production volume	
CLOTHES DISPOSED OF	Clothes disposed of	48	million tonnes	Clothes that are disposed of, no matter the destination (e.g., charity, bin, etc.) - assumed to be equivalent to the amount of sales volume every given year	Assumption
RETAILER OVERSTOCK LIQUIDATED INTO LANDFILL OR INCINERATION ³	% of retailer overstock liquidated	3	%	Share of retailer stock that is liquidated to incineration/landfill each given year	Obsolete inventory in Dutch clothing industry (Thesis)
	x				
	Clothes disposed of	48	million tonnes		
	=				
	Retailer overstock liquidated into landfill or incineration	1	million tonnes	Assuming retailer overstock liquidated is part of disposed clothes	

POST-USE DISPOSED CLOTHES LANDFILLED OR INCINERATED	Share of clothes landfilled or incinerated	73	%	Share of textile or clothing landfilled or incinerated in the seven largest consumption regions. Mass landfilled is assumed to be the % of clothes that does not end up being collected, incinerated, or in overstock liquidation	Press search
	x				
	Clothes disposed of	48	million tonnes		
	-				
	Retailer overstock liquidated into landfill or incineration	1	million tonnes		
	=				
Post-use clothes landfilled or incinerated (not valorised)	35	million tonnes			
CLOTHES COLLECTED	Share of clothes collected	25	%	Share of clothes that are collected by any type of organisation that handles used clothes (not wasted) ⁴	McKinsey analysis
	x				
	Clothes disposed of	48	million tonnes		
	=				
LOSSES IN COLLECTION	Clothes collected	12	million tonnes	See above	
	x				
	Loss rate in collection	7.5	%	Material losses incurred in collection e.g., due to part of materials being unusable, damaged or lost in collection, sorting or recycling steps	
	=				
CLOTHES REUSED ⁵	Process losses in collection	1	million tonnes		
	Share of clothes reused (of disposed)	12	%	Share of clothing reused for second hand markets for the seven largest consumption regions, out of total disposed clothes	Press search
	x				
	Clothes disposed of	48	million tonnes	See above	
CLOTHES SENT OVERSEAS FOR REUSE	=				
	Clothes reused	6	million tonnes	Clothes that are reused again in their exact same state with no (or minimal) reworking. For the percentages of the material flows, this amount is further broken down for final destination	
	Clothes reused	6	million tonnes	See above	Calculation, Expert interviews, press search
	x				
CLOTHES REUSED DOMESTICALLY	Share of reused sent overseas	75	%	% of clothes sent overseas for reuse	
	=				
	Clothes sent overseas for reuse	4	million tonnes		
	Clothes reused	6	million tonnes	See above	
CLOTHES REUSED DOMESTICALLY	x				
	Clothes sent overseas	4	million tonnes	See above	
	=				
	Clothes reused domestically	2	million tonnes		

CLOTHES RECYCLED	Share of discarded clothes going to recycling	14	%	Share of clothes going to recycling, aggregation of figures from different countries	McKinsey analysis
	x				
	Clothes disposed of	48	million tonnes	See above	
	-				
	Process losses in collection	1	million tonnes	See above. Assuming all losses in collection apply only to material collected for recycling	
	=				
	Clothes recycled	6	million tonnes		
FIBRES RECYCLED BACK INTO FIBRES FOR CLOTHING PRODUCTION	Share of recycled inputs in clothing production	< 1	%	% of fibres recycled back into the clothing production - assumed to be equivalent to the amount of inputs into fibre production that are recycled-based ⁶	Expert interviews, press search
	x				
	Total fibre inputs	53	million tonnes	See above	
	=				
	Fibres recycled back into clothing	< 0.5	million tonnes	Amount of fibres recycled back in the clothing industry	
CLOTHES TO CASCADING	Clothes recycled	6	million tonnes	See above	
	-				
	Clothes recycled back in to fibres for clothing production	< 0.5	million tonnes	See above	McKinsey analysis
	=				
	Clothes downcycled	6	million tonnes	Clothing fibres that exit the clothing industry to be recycled for another industrial purpose (e.g., rags, insulation, automotive parts)	
RECYCLED FIBRES FOR CLOTHING PRODUCTION	Share of recycled plastic-based fibres	3	%	Share of plastic-based fibres for clothing that are recycled	IHS, Wood McKenzie
	x				
	Total tonnes of plastic-based fibres in clothing production	33	million tonnes	See above	
	=				
	Recycled fibres as input in clothing production	1	million tonnes	Amount of recycled fibres, assuming plastic-based recycled fibres make up for the vast majority of recycled fibres for clothing	Expert interviews, press search

1 Rough estimate - estimates of volume loss between fibres and textile production vary. E.g., Gherzi estimates total material loss between global fibre and textile production is from 89 million tonnes to 8.6 million tonnes, equivalent to 3% loss between steps. Not all material is necessarily incinerated or landfilled - some likely to be cascaded

2 In theory the assumption is that production equals sales, yet in practice there can be discrepancy between volume produced and retail volume as both data points come from different data sources (IEMI and Euromonitor respectively). While, production data is used for most purposes, for specific sales and use analyses, no. of units sold is used

3 Retailers at times produce in excess - which then needs to be liquidated. Some overstock liquidated in terms of being sold at e.g., outlets or recycled - but part is liquidated by either incineration or landfilling - variable is looking at this specific proportion

4 Rounding

5 Note: in global materials flow diagram, it is assumed that in the long run reused clothes will also end up either landfilled, incinerated, cascaded or loop-to-loop recycled - thus 6 million of reused clothing is distributed based on percentage split, between each end-of-life destination. The splits differs according to whether the clothes are reused domestically or overseas.

6 Some experts estimate the share to be even lower, e.g. below 0.1%

Appendix B.2: Resource use and negative externalities associated with material flows

ASSUMPTIONS ON TEXTILES PRODUCTION AND METHODOLOGY

INPUT	STEPS FOR CALCULATION	VALUE	UNIT	COMMENT	SOURCE
COTTON	Total cotton production	20	million tonnes	Total cotton production - figures for 2014 used to better reflect long-run average	USDA
	x				
	Share of cotton production going to textile production	90	%	Applying the global share of fibres going into textiles, assuming it applies to each of the three fibre types	Lenzing, assumption
	=				
	Cotton production for textiles	45	million tonnes		
PLASTIC-BASED FIBRES	Total plastic-based fibres production	50	million tonnes	Total plastic-based fibres production	IHS
	x				
	Share of plastic-based fibres going to textile production	90	%	Applying the global share of fibres going into textiles, assuming it applies to each of the three fibre types	Lenzing, assumption
	=				
	Plastic-based fibres production for textiles	18	million tonnes		
OTHERS	Plastic-based and cotton production for textiles	70	million tonnes	Sum of both cotton and plastic-based fibres production, see above	
	/				
	(% of other fibres) / (1 - % of other fibres)	12	%	Share of other fibres (not plastic-based, not cotton) of total fibre production, 2014	Gherzi
	=				
	Other fibres production for textiles	9	million tonnes	Total tonnes of fibres other than cotton and plastic-based fibres going into textile production	

ASSUMPTIONS ON GREENHOUSE GAS EMISSIONS

INPUT	STEPS FOR CALCULATION	VALUE	UNIT	COMMENT	SOURCE	
CO ₂ e EMISSIONS - FIBRE PRODUCTION PHASE	Cotton production for textiles	18	million tonnes			
	x					
	GHG emissions for cotton production	4.7	kg CO ₂ e/kg fibre		McKinsey analysis	
	=					
	Total GHG emissions for cotton production for textiles	86	million tonnes CO ₂ e			
	+	Plastic-based fibres production for textiles	45	million tonnes		
	x					
	GHG emissions for plastic-based fibres production	11.9	kg CO ₂ e/kg fibre		McKinsey analysis	
	=					
	Total GHG emissions for plastic-based fibres production for textiles	530	million tonnes CO ₂ e			
	+	Other fibres production for textiles	9	million tonnes		
	x					
	GHG emissions for other fibres production	4.7	kg CO ₂ e/kg fibre	Assumed same as the lowest of cotton / plastic-based	Conservative assumption	
	=					
	Total GHG emissions for other fibres production for textiles	40	million tonnes CO ₂ e			
+	Total fibres produced for textiles	71	million tonnes			
x						
GHG emissions for yarn production, dyeing, weaving and knitting	9.6	kg CO ₂ e/kg fibre		McKinsey analysis		
=						
Total GHG emissions for yarn production, dyeing, weaving and knitting	550	million tonnes CO ₂ e				
+	Total GHG emissions in textiles production	1.2	GT CO ₂ e			
TOTAL						

ASSUMPTIONS ON WATER USAGE

INPUT		STEPS FOR CALCULATION	VALUE	UNIT	COMMENT	SOURCE
WATER - FIBRE PRODUCTION PHASE		Cotton production for textiles	18	million tonnes		
		x				
		Water for cotton production	4600	litre/kg fibre		McKinsey analysis
		=				
		Total water for cotton production for textiles	84.5	billion cubic metres		
	+	Plastic-based fibres production for textiles	45	million tonnes		
		x				
		Water for plastic-based fibres production	38	litre/kg fibre		McKinsey analysis
		=				
		Total water for plastic-based fibres production for textiles	1.7	billion cubic metres		
	+	Total other fibres produced for textiles	9	million tonnes		
		x				
		Water for other fibres production	38	litre/kg fibre	Assumed same as the lowest of cotton / plastic-based	Conservative assumption
		=				
		Total water for other fibres production for textiles	0.3	billion cubic metres		
+	Total fibres produced for textiles	71	million tonnes			
	x					
	Water for dyeing	88	litre/kg fibre		McKinsey analysis	
	=					
	Total water for dyeing	6.3	billion cubic metres			
=	Total water in textiles production	93	billion cubic metres			
TOTAL						

ASSUMPTIONS ON FERTILISERS, PESTICIDES, AND OIL FEEDSTOCK

INPUT	STEPS FOR CALCULATION	VALUE	UNIT	COMMENT	SOURCE
FERTILISERS	Weighted average application rate for cotton globally	0.257	tonnes/ha		F. Rosas "Fertilizer Use by Crop at the Country level (1990 - 2010)" (2012)
	x				
	World arable land	1417	million ha		FAOSTAT "Composition of agricultural area dataset" (2016)
	x				
	Cotton share of arable land	2.4	%		WWF "The Impact of Cotton on Freshwater Resources and Ecosystems" (1999)
	x				
	Share of cotton production going to textile production	90	%	Applying the global share of fibres going into textiles, assuming it applies to each of the three fibre types	
	=				
Total tonnes of fertilisers for textiles production	8	million tonnes			
PESTICIDES	Pesticides consumed globally	2	million tonnes		A. De, R Bose et al "World Pesticide Use" (2013)
	x				
	Share of pesticides going to cotton	11	%		WWF "The Impact of Cotton on Freshwater Resources and Ecosystems" (1999)
	x				
	Share of cotton production going to textile production	90	%	Applying the global share of fibres going into textiles, assuming it applies to each of the three fibre types	Lenzing, Assumption
	=				
Total pesticides for textiles production	200	thousand tonnes			
OIL - PLASTIC-BASED FIBRES FEEDSTOCK	Total tonnes of fertilisers for textiles production	8	million tonnes	Based on ammonia (NH ₃) production, NH ₃ is the most energy intensive fertiliser. Based on gas, oil and coal use/ tonne NH ₃ produced	Industrial Efficiency Technology Database
	x				
	Energetic input for fertiliser production	0.9	kg/kg of fertiliser		
	=				
	Total fossil feedstock for fertilisers production	7	million tonnes		Calculation
	Plastic-based fibres production for textiles	45	million tonnes		
	x				
	Oil required for plastic-based fibres	1.1	kg/kg of plastic-based fibre	Arithmetic average from three sources	S. Muthu, B. Gervet
	=				
	Total oil feedstock for plastic-based fibres production	48	million tonnes		
Total fossil feedstock for fibres production for textiles	55	million tonnes			

ASSUMPTIONS ON CHEMICALS AND DYES USAGE

INPUT	STEPS FOR CALCULATION	VALUE	UNIT	COMMENT	SOURCE
CHEMICALS	Cotton production for textiles	18	million tonnes		
	x				
	Chemical input required for cotton textile	925	g/kg of cotton-based textile	Arithmetic average of range of 350 - 1500	Blusign
	=				
	Total chemical input for cotton-based textile production	17	million tonnes		
	+				
	Plastic-based fibres production for textiles	45	million tonnes		
	x				
	Chemical input required for plastic-based textile	465	g/kg of plastic-based textile	Arithmetic average of range of 110 - 820	Blusign
	=				
	Total chemical input for plastic-based textile production	21	million tonnes		
	+				
	Cotton production for textiles	9	million tonnes		
	x				
	Chemical input required for textile based on other fibres	465	g/kg of other fibres textile	Assumed same as the lowest of cotton / plastic-based	Conservative assumption
=					
Total chemical input for the production of textiles based on other fibres	4	million tonnes			
+					
Total chemical input in textiles production	42	million tonnes			
DYES	Dyes consumption per kg	20	kg per tonne of fabric	2014 values	M. Morhsed "RFT Dyeing & Its Effect" (2015)
	x				
	Total fabric production	51	million tonnes		
	=				
	Total dye consumption in textiles production	1	million tonnes		

Appendix B.3. Extrapolations to 2050

METHODOLOGY AND KEY ASSUMPTIONS FOR EXTRAPOLATIONS TO 2050

METHODOLOGY					
<ul style="list-style-type: none"> Apply growth rate forecast per fibre type for the period 2015-2020 Extrapolate until 2050 Isolate externalities per fibre type and scale them to the projected mass of fibres 					
KEY ASSUMPTIONS					
INPUT		METRIC	VALUE	DESCRIPTION	SOURCE
	Annual growth rate for underlying material volume	Plastic-based fibres	3.5%	Growth rate based on the forecast of the textiles and clothing industry for the period 2015-2020 This rate has been used as CAGR to extrapolate 2015 baselines until 2050	Textile Exchange
		Cotton	1.5%		
		Others	5.5%		
	Total fibres CAGR	CAGR 2015-2050 for all fibres	3.5%	Resulting from the growth rates above	
	Fibre shares in 2050	Plastic-based fibres	63%	Resulting from the growth rates above	
		Cotton	13%		
Others		24%			

ENDNOTES

- 1 Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005–2015); <https://www.worldwildlife.org/industries/cotton>; Fashion United, *Global industry fashion statistics: International apparel* (2016), <https://fashionunited.com/global-fashion-industry-statistics>
- 2 Excluding footwear
- 3 Wood Mackenzie presentation, *Product developments in manmade fibres: Is cotton able to compete?* (2016)
- 4 This is true for plastic-based fibres, but also for cellulose-based fibres such as cotton, which usually requires fossil-based fertilisers and pesticides.
- 5 McKinsey & Company, *Style that's sustainable: A new fast-fashion formula* (2016)
- 6 Global Fashion Agenda and Boston Consulting Group, *Pulse of the fashion industry* (2017), p.19
- 7 Circular Fibres Initiative analysis based on Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005–2015). All numbers include all uses until the garment is discarded, including reuse after collection and resale.
- 8 Ibid.
- 9 Calculation based on Circular Fibres Initiative materials flow analysis (for details see Appendix B) and Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005–2015). In 2015, 46% (in mass) of collected garments were reused. If 100% of discarded clothing were collected, 22.2 million tonnes would be reused instead of 5.6 million tonnes as at present, meaning 16.6 million tonnes of new garment sales would be avoided, with a value of USD 460 billion.
- 10 Barnardo's, *Survey of 1500 women as part of #MyBarnardosDonation - Campaign* (2015); Morgan, L.R. and Birtwistle, G., *An investigation of young fashion consumers' disposal habits* (2009)
- 11 Greenpeace, *After the binge, the hangover: Insights into the minds of clothing consumers* (2017), p.4; WRAP, *Clothing durability report* (2017), p.15
- 12 Circular Fibres Initiative materials flow analysis (for details see Appendix B)
- 13 This includes recycling after use, as well as the recycling of factory offcuts. Expert interviews and some reports suggest that the rate of recycling clothing after use could be below 0.1% (see, e.g. Wicker, A., *Fast fashion is creating an environmental crisis*, Newsweek (1 September 2016)).
- 14 Estimate based on Circular Fibres Initiative analysis on the share of materials and on a price of USD 2.8/kg for cotton yarn and USD 1.7/kg for polyester yarn (see <http://www.globaltexassociates.com/price.html>).
- 15 WRAP, *Evaluation of the end markets for textile rag and fibre within the UK* (2014), p.8
- 16 See, for example, Watson, D., et al., *Exports of Nordic used textiles: Fate, benefits and impacts* (2016)
- 17 Fachverband Textilrecycling, *Konsum, Bedarf und Wiederverwendung von Bekleidung und Textilien in Deutschland* (2016), p.37
- 18 Watson, D., et al., *Exports of Nordic used textiles: Fate, benefits and impacts* (2016), p.67
- 19 Circular Fibres Initiative analysis – for details see Part I of this report
- 20 Ibid.
- 21 Circular Fibres Initiative analysis – for details see Appendix B
- 22 International Energy Agency, *Energy, Climate Change & Environment: 2016 insights* (2016), p.113
- 23 Kant, R., *Textile dyeing industry: An environmental hazard*, Natural Science, Vol. 4, 1 (2012), p.23
- 24 O'Connor, M.C., *Inside the lonely fight against the biggest environmental problem you've never heard of*, The Guardian (27 October 2014); International Union for Conservation of Nature, *Primary microplastics in the oceans: A global evaluation of sources* (2017), pp.20–21
- 25 Kamath, N., *Handbook of research on strategic supply chain management in the retail industry* (2016); GS1 UK, *Where did your profitability go? Managing the apparel omnichannel cost-to-serve* (2016), p.13
- 26 Greenpeace, *Time out for fast fashion* (2016), p.3; Doane, D., *Living in the background: Home-based women workers and poverty persistence* (2007)
- 27 Bureau of International Labor Affairs, *Findings on the worst forms of child labor* (2013), pp.10, 30, 31, 56, 59, 110, 146, 171, 368, 369, 561, 775, 776; Verité, *Help Wanted* (2010), p.5; Anti-Slavery International, *Slavery on the high street* (2012); see <http://www.safia-minney.com/slave-to-fashion.html>; <https://labs.theguardian.com/unicef-child-labour>
- 28 See Appendix B.3 for assumptions and methodology behind the extrapolations in this section
- 29 Compared to the IEA 2°C pathway 2050 which allows for 15.3 giga tonnes of CO₂ equivalent
- 30 Global Fashion Agenda and Boston Consulting Group, *Pulse of the fashion industry* (2017), p.23
- 31 Kasperkevic, J., *Rana Plaza collapse: Workplace dangers persist three years later, reports find*, The Guardian (31 May 2016)
- 32 See, for example, <http://www.greenpeace.org/international/en/campaigns/detox>; Changing Markets Foundation *Dirty fashion: How pollution in the textiles supply chain is making viscose toxic* (2017); WRAP, *Valuing Our Clothes: The cost of UK fashion* (2017); Greenpeace, *Time out for fast fashion* (2016)
- 33 Greenpeace, *Fashion at the crossroads* (2017)
- 34 See <https://www.ellenmacarthurfoundation.org/circular-economy/overview/concept>
- 35 These benefits have been investigated for example in: Ellen MacArthur Foundation, *Circular economy in India: Rethinking growth for long-term prosperity* (2016) and Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: A circular economy vision for a competitive Europe* (2015)
- 36 Estimate based on the material cost of yarn
- 37 See <https://newplasticseconomy.org>
- 38 See, for example, Greenpeace, *Time out for fast fashion* (2016); Changing Markets Foundation, *Dirty fashion: How pollution in the textiles supply chain is making viscose toxic* (2017); Global Fashion Agenda and Boston Consulting Group, *Pulse of the fashion industry* (2017); WRAP, *Valuing our clothes: The cost of UK fashion* (2017); Fashion for Good, *The five goods* (2017), <https://fashionforgood.org/the-five-goods>; GLASA, *The state of the apparel sector* (2013)
- 39 William Arthur Ward

- 40 See, for example, Global Fashion Agenda and Boston Consulting Group, *Pulse of the fashion industry* (2017), p.74; Fletcher, K., *Sustainable fashion and textiles: Design journeys*, second edition (2014); Greenpeace, *Fashion at the crossroads* (2017)
- 41 See <https://www.copenhagenfashionsummit.com/commitment>
- 42 See <http://www.greenpeace.org/international/en/campaigns/detox/fashion/detox-catwalk>
- 43 See <http://reloopingfashion.org>
- 44 See <http://mistrafuturefashion.com>
- 45 See <http://www.wrap.org.uk/category/materials-and-products/textiles>
- 46 See <http://www.fashionpositive.org>
- 47 See <http://www.europeanoutdoorgroup.com/news/outdoor-industry-microfibre-consortium-formed>
- 48 See <https://fashionforgood.com>
- 49 See <https://www.changemakers.com/fabricofchange>
- 50 See <https://globalchangeaward.com/articles/about>
- 51 See http://ec.europa.eu/environment/circular-economy/index_en.htm
- 52 See <http://www.apparalcoalition.org/the-higg-index>
- 53 Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005–2015); <https://www.worldwildlife.org/industries/cotton>
- 54 McKinsey, *Style that's sustainable: A new fast-fashion formula* (2016)
- 55 Circular Fibres Initiative analysis based on Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005–2015). All figures include all uses until the garment is discarded, including reuse after collection and resale.
- 56 Calculation based on Circular Fibres Initiative materials flow analysis (for details see Appendix B) and Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005–2015). In 2015, 46% (in mass) of collected garments were reused. If 100% of discarded clothing were collected, 22.2 million tonnes would be reused instead of 5.6 million tonnes as at present, meaning 16.6 million tonnes of new garment sales would be avoided, with a value of USD 460 billion.
- 57 Barnardo's, *Once worn thrice shy* (2015), http://www.barnardos.org.uk/news/press_releases.htm?ref=105244; Morgan, L.R. and Birtwistle, G., *An investigation of young fashion consumers' disposal habits* (2009)
- 58 Greenpeace, *After the binge, the hangover: Insights into the minds of clothing consumers* (2017); WRAP, *Clothing durability report* (2017)
- 59 Estimate based on Circular Fibres Initiative analysis on the share of materials and on a price of USD 2.8/kg for cotton yarn and USD 1.7/kg for polyester yarn (see <http://www.globaltextassociates.com/price.html>).
- 60 Recent research indicates that this might be an underestimation. Field research analysing waste from seven garment factories carried out by the innovator Reverse Resources concluded that on average 25% of material is lost during production; see Reverse Resources, *The Undiscovered Business Potential of Production Leftovers within Global Fashion Supply Chains: Creating a Digitally Enhanced Circular Economy* (2017), p.6.
- 61 Based on an average density of 150kg/m³ for a bale of textiles and a volume of 17.5m³ of a garbage truck
- 62 Wicker, A., *Fast fashion is creating an environmental crisis*, Newsweek (9 January 2016)
- 63 WRAP, *Evaluation of the end markets for textile rag and fibre within the UK* (2014), p.8
- 64 See e.g. Wicker, A., *Fast fashion is creating an environmental crisis*, Newsweek (1 September 2016); expert interviews
- 65 World Economic Forum, Ellen MacArthur Foundation, and McKinsey & Company, *The New Plastics Economy: Rethinking the future of plastics* (2016), p.27
- 66 Oakdene Hollins, *Closed loop fibre recycling: Current status and future challenges* (2013)
- 67 Circular Fibres Initiative analysis – for details see Appendix B
- 68 Fachverband Textilrecycling, *Konsum, Bedarf und Wiederverwendung von Bekleidung und Textilien in Deutschland* (2016), p.37
- 69 See <http://weardonaterecycle.org/about/issue.html>; http://hb.sina.com.cn/news/d/2013-07-11/152689575_3.html; <http://www.chinacace.org/news/view?id=8152>
- 70 Watson, D., et al., *Exports of Nordic used textiles: Fate, benefits and impacts* (2016), pp.121, 156
- 71 In 2015, 33 billion barrels of oil were produced, 4% of total oil production is used to produce plastics, of which 25% becomes textiles (see Nordic Fashion Association, *Polyester and synthetics*; Statista, *Global oil production from 1998 to 2015* (2017), <https://www.statista.com/statistics/265203/global-oil-production-since-in-barrels-per-day/>). Figure averaged with other sources: Muthu, S., *Roadmap to Sustainable Textiles and Clothing: Eco-friendly Raw Materials, Technologies and Processing Methods* (2014); Gervet, B., *The use of crude oil in plastic making contributes to global warming* (2007)
- 72 Globally, around 2 million tonnes of pesticides consumed, of which 11% are used for cotton farming. (De, A., et al., *World pesticide use* (2013); WWF, *The impact of cotton on freshwater resources and ecosystems* (1999); FAOSTAT, *Composition of agricultural area dataset* (2016)); average fertiliser application rates per hectare of cotton weighted by main producing countries, multiplied by hectares of world arable land times cotton share of arable land (see Rosas, F., *Fertilizer use by crop at the country level (1990–2010)* (2012)).
- 73 For every kilogram of fabric, an estimated 0.58kg of various chemicals are used. For example, 0.35–1.5kg of chemicals goes into the production of 1kg of cotton textiles (see Bluesign, *Environmental Health & Safety (EHS) guidelines for brands and retailers* (2011)).
- 74 Rodale Institute, *Dig deeper: Chemical cotton* (4 February 2014), <http://rodaleinstitute.org/chemical-cotton>
- 75 Maxwell, D., et al., *State of the apparel sector report: Water*, GLASA (2015), p.14; Dey, K.R., et al., *Impact of pesticide use on the health of farmers: A study in Barak valley, Assam* (2013)
- 76 See <http://www.pan-uk.org/cotton>
- 77 Yallop, O., *Citarum, the most polluted river in the world?*, The Telegraph (11 April 2014)
- 78 See <https://www.acs.org/content/acs/en/pressroom/presspac/2016/acs-presspac-january-27-2016/creating-greener-wrinkle-resistant-cotton-fabric.html>
- 79 Piccinini, P., et al., *European survey on the release of formaldehyde from textiles* (2007)
- 80 Global Fashion Agenda and Boston Consulting Group, *Pulse of the fashion industry* (2017), p.46
- 81 Circular Fibres Initiative analysis – for details see Appendix B

- 82 International Energy Agency, *Energy, Climate Change & Environment: 2016 insights* (2016), p113
- 83 Eunomia, *The potential contribution of waste management to a low carbon economy* (2015)
- 84 Calculation based on Circular Fibres Initiative analysis and following sources: Pakula, C., Stammering, R., *Electricity and water consumption for laundry washing by washing machine worldwide* (2009); Dupont, *Consumer Laundry Study* (2013)
- 85 World Bank, AQUASTAT, and FAO, *Dataset: Annual freshwater withdrawals, total* (2014)
- 86 Gassert, F., et al., *Water stress by country*, WRI Aqueduct (2013)
- 87 Maxwell, D., et al., *State of the apparel sector report: Water*, GLASA (2015), p.43
- 88 Calculation based on Circular Fibres Initiative analysis and following sources: Pakula, C., Stammering, R., *Electricity and water consumption for laundry washing by washing machine worldwide* (2009)
- 89 Maxwell, D., et al., *State of the apparel sector report: Water*, GLASA (2015), p.23; Rodale Institute, *Dig deeper: Chemical cotton* (4 February 2014), <http://rodaleinstitute.org/chemical-cotton>
- 90 Department for Environment, Food and Rural Affairs, *The role and business case for existing and emerging fibres in sustainable clothing* (2007), p.75
- 91 Maxwell, D., et al., *State of the apparel sector report: Water*, GLASA (2015), p.14
- 92 International Union for Conservation of Nature, *Primary microplastics in the oceans: A global evaluation of sources* (2017)
- 93 Based on the central scenario in International Union for Conservation of Nature, *Primary microplastics in the oceans: A global evaluation of sources* (2017), p.20. Their analysis is based on two different approaches, one based on the estimated number of wash cycles per region, the other based on global textile sales, which come to similar results (see p.34 in their study). A separate Circular Fibres Initiative analysis led to similar results. Another study for the EU Commission (Eunomia Research & Consulting Ltd., *Study to support the development of measures to combat a range of marine litter sources*, report for DG Environment of the European Commission (2016), p.272 ff.) estimates 30,000 tonnes per year in Europe alone. Plastic bottle comparison based on an average weight of 10 gram of a 0.5 litres PET bottle.
- 94 Kamath, N., *Handbook of research on strategic supply chain management in the retail industry* (2016)
- 95 Greenpeace, *Time out for fast fashion* (2016); Doane, D., *Living in the background: Home-based women workers and poverty persistence* (2007)
- 96 Bureau of International Labor Affairs, *Findings on the worst forms of child labor* (2013), pp.10, 30, 31, 56, 59, 110, 146, 171, 368, 369, 561, 775, 776; Moulds, J., *Child labour in the fashion supply chain*, The Guardian; Verité, *Help wanted* (2010), p.5; Anti-Slavery International, *Slavery on the high street* (2012); <http://www.safia-minney.com/slave-to-fashion.html>
- 97 Human Rights Watch, *Whoever raises their head suffers the most* (2015), p.4
- 98 See <https://sourcingjournalonline.com/textile-factories-contaminate-indonesias-citarum-river>; <http://www.greenpeace.org/eastasia/campaigns/toxics/problems/water-pollution>
- 99 See Appendix B.3 for assumptions and methodology for the extrapolations in this section
- 100 Compared to the IEA 2°C pathway 2050 which allows for 15.3 giga tonnes of CO₂ equivalent
- 101 Based on an average weight of 180 grams
- 102 Maxwell, D., et al., *State of the apparel sector report: Water*, GLASA (2015), pp.4, 31
- 103 Based on a weight of today's world population of 300 million tonnes
- 104 Global Fashion Agenda and Boston Consulting Group, *Pulse of the fashion industry* (2017), p.23
- 105 Ibid., p.2
- 106 Kasperkevic, J., *Rana Plaza collapse: Workplace dangers persist three years later, reports find*, The Guardian (31 May 2016)
- 107 See <http://www.greenpeace.org/international/en/campaigns/detox>
- 108 Greenpeace, *Fashion at the crossroads* (2017)
- 109 See <http://fashionrevolution.org/about>
- 110 Ellen MacArthur Foundation, *Towards a circular economy*, Vols. 1-3 (2012-2015)
- 111 Some of the recent literature includes: Circle Economy and EHERO, *Circular jobs: Understanding employment in the circular economy in the Netherlands* (2016); Sitra, *Leading the cycle: Finnish road map to a circular economy 2016-2025* (2016); European Environment Agency, *Circular economy in Europe* (2016); Dutch Ministry of Infrastructure and Environment and Dutch Ministry of Economic Affairs, *A circular economy in the Netherlands by 2050* (2016); Club of Rome, *The circular economy and benefits for society* (2016); Green Alliance, *Unemployment and the circular economy in Europe* (2015); US Chamber of Commerce Foundation, *Achieving a circular economy: How the private sector is remaking the future of business* (2015); WRAP, *Economic growth potential of more circular economies* (2015); Green Alliance, *The social benefits of a circular economy: Lessons from the UK* (2015); Zero Waste Scotland, *The carbon impacts of the circular economy* (2015); Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: A circular economy vision for a competitive Europe* (2015); WRAP and Green Alliance, *Employment and the circular economy* (2015); Cambridge Econometrics and Bio Intelligence Service, *Study on modelling of the economic and environmental impacts of raw material consumption* (2014); Netherlands Organisation for Applied Scientific Research, *Opportunities for a circular economy in the Netherlands* (2013)
- 112 See, for example, Tearfund and Institute of Development Studies, *Virtuous circle: How the circular economy can create jobs and save lives in low and middle-income countries* (2016); specifically for India, Ellen MacArthur Foundation, *Circular economy in India: Rethinking growth for long-term prosperity* (2016); and, specifically for China, the forthcoming report Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China*
- 113 For an overview, see Ellen MacArthur Foundation, *Towards a circular economy: Business rationale for an accelerated transition* (2016), pp.10-15
- 114 As an example, such an analysis (based on economic modelling using a computable general equilibrium model) for the EU economy in three sectors (food, built environment, and mobility) has shown reduced annual cash-out costs of EUR 0.6 trillion (4.5% of the EU's GDP) and a GDP increase of 7% in 2030 (see Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: A circular economy vision for a competitive Europe* (2015), pp.11-12).

- 115 Such a relationship has been investigated for certain other human needs in specific regions. For example, analysis (based on economic modelling using a computable general equilibrium model) found that implementing circular economy opportunities in three sectors (food, built environment, and mobility) in the EU would lead to 10% more disposable household income in 2030 (see Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment, *Growth Within: A circular economy vision for a competitive Europe* (2015), p.30). In another example, an analysis for India found that the per capita cost to meet the same level of mobility demand would be 29% lower in 2030 and 54% lower in 2050 (see Ellen MacArthur Foundation, *Circular economy in India: Rethinking growth for long-term prosperity* (2016), p.59).
- 116 Khan, S. and Malik, A., *Environmental and Health Effects of Textile Industry Wastewater* (2013); Akarslana, F. and Demiralayb, H., *Effects of Textile Materials Harmful to Human Health* (2015)
- 117 For a description of biodegradation and anaerobic digestion, see, for example, Appendices B and C in World Economic Forum, Ellen MacArthur Foundation, and McKinsey & Company, *The New Plastics Economy: Rethinking the future of plastics* (2016)
- 118 Weber, C.J., *Biobased packaging materials for the food industry: Status and perspectives* (2000), p.108
- 119 Gauto, A., *Freitag macht neben Taschen jetzt auch bio-Mode*, WirtschaftsWoche (2017)
- 120 Ellen MacArthur Foundation, *Towards the circular economy*, Vol. 2 (2013), p.57
- 121 Mistra Future Fashion, *Filippa K & Mistra Future Fashion in a groundbreaking new industry research project for the future of fashion* (4 May 2017), <http://mistrafuturefashion.com/circular-design-speeds>
- 122 Kant, R., *Textile dyeing industry: An environmental hazard* (2012), p.23
- 123 Greenpeace, *Dirty laundry: Unravelling the corporate connections to toxic water pollution in China* (2011), pp.6, 52
- 124 Chemsec, *The bigger picture: Assessing economic aspects of chemicals substitution* (2016), p.13
- 125 For the purposes of this report, 'substances of concern' refers to substances that cause concern due to adverse or potential adverse impacts on human health or the environment. This definition is broader than the European Union REACH Legislation definition of Substances of Very High Concern (SVHC) (see <https://echa.europa.eu/chemicals-in-our-life/which-chemicals-are-of-concern/svhc>). Substances that may have serious effects on human health and the environment can be identified as SVHCs. These are primarily substances which are carcinogenic, mutagenic, or toxic to reproduction, as well as substances with persistent and bio-accumulative characteristics.
- 126 KEMI, *Hazardous chemical substances in textiles: Proposals for risk management measures* (2016), p.30
- 127 For every kilogram of fabric, an estimated 0.58kg of various chemicals are used. Between 0.35 and 1.5kg of chemicals go into the production of 1kg of cotton textile (see Bluesign, *Environmental Health & Safety (EHS) guidelines for brands and retailers* (2011)).
- 128 PRN Newswire, *Textile chemicals market to reach US\$29.15 billion by 2024* (6 May 2016); Euroonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005-2015)
- 129 Greenpeace, *Dirty laundry: Unravelling the corporate connections to toxic water pollution in China* (2011), p.70
- 130 KEMI, *Chemicals in textiles: Risks to human health and the environment* (2014); <http://www.greenpeace.org/international/en/campaigns/detox/fashion/about/eleven-flagship-hazardous-chemicals>; Changing Markets Foundation, *Dirty fashion: How pollution in the textiles supply chain is making viscose toxic* (2017)
- 131 See <http://www.greenpeace.org/international/en/campaigns/detox/fashion/about/eleven-flagship-hazardous-chemicals>
- 132 Environmental Leader, *Assessing the impact of the fashion world* (2014)
- 133 Fashion For Good, *C2C Certified 'how-to' guide* (2017); Greenpeace, *Dirty laundry: Unravelling the corporate connections to toxic water pollution in China* (2011), p.6
- 134 Examples exist of yarn producers using antimony-free polyester, for example Polyterra or Polyteks.
- 135 New Jersey Department of Health and Senior Services, *Hazardous substance fact sheet: Antimony trioxide* (2004); <https://echa.europa.eu/information-on-chemicals/cli-inventory-database/-/discli/details/16879>
- 136 Greenpeace, *Hazardous chemicals in branded luxury textile products on sale during 2013* (2014), p.18
- 137 Chemsec, *The bigger picture: Assessing economic aspects of chemicals substitution* (2016), p.13
- 138 Global Fashion Agenda and Boston Consulting Group, *Pulse of the fashion industry* (2017), p.21, assessment included monetary impacts associated with occupational illnesses attributed to carcinogens and airborne particulates
- 139 Ellen MacArthur Foundation, World Economic Forum, and McKinsey & Company, *The New Plastics Economy: Rethinking the future of plastics* (2016)
- 140 KEMI, *Chemicals in textiles: Risks to human health and the environment* (2014), p.31
- 141 Weber, C.J., *Biobased packaging materials for the food industry: Status and perspectives* (2000), p.108
- 142 Roberts G., Chemical Watch, *Big brands quiz suppliers on chemicals in textiles*, Chemical Watch (September 2013); see <http://www.roadmaptozero.com/contributors>
- 143 Chemsec, *Textiles come with a toxic footprint* (2017), <http://textileguide.chemsec.org/find/textiles-come-with-a-toxic-footprint>
- 144 The Stockholm Convention on Persistent Organic Pollutants is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment (see <http://www.chm.pops.int/TheConvention/Overview>).
- 145 Pesticide Action Network, *Cotton without highly hazardous pesticides: An Ethiopian experience* (2017), p.1
- 146 Changing Markets Foundation, *Dirty fashion: How pollution in the textiles supply chain is making viscose toxic* (2017); Gelbke, H.P., et al., *A review of health effects of carbon disulfide in viscose industry and a proposal for an occupational exposure limit* (2009), p.1
- 147 KEMI, *Hazardous chemical substances in textiles: Proposals for risk management measures* (2016), p.17
- 148 See https://newsletter.echa.europa.eu/home/-/newsletter/entry/1_13_textile
- 149 Davies, A., *An evaluation of the test methods used for assessing durable water repellent fabrics within the outdoor industry* (2014), p.5; Patagonia, *The footprint chronicles: PFOS, PFOA, and other fluorochemicals* (2013), p.1

- 150 Greenpeace, *Hidden in plain sight: Poly-fluorinated chemicals (PFCs) in the air of outdoor stores* (2016), p.4
- 151 Fei, C., et al., *Maternal levels of perfluorinated chemicals and subfecundity*, Human Reproduction, Vol. 24, 5 (2009), pp.1200-1205; Nordström Joensen, U., et al., *Do perfluoroalkyl compounds impair human semen quality?*, Environmental Health Perspectives, 117 (2009), pp.923-927; Granjean, P., et al., *Serum vaccine antibody concentrations in children exposed to perfluorinated compounds*, JAMA, Vol. 307, 4 (2012), pp.391-397
- 152 Wang, Z., et al., *Fluorinated alternatives to longchain perfluoroalkyl carboxylic acids (PFCA)s, perfluoroalkane sulfonic acids (PFSA)s and their potential precursors* (2013), pp.242-248
- 153 Chemical Watch, *PFHxS added to REACH candidate list* (2017)
- 154 KEMI, *Chemicals in textiles: Risks to human health and the environment* (2014), p.9
- 155 Rodale Institute, *Dig deeper: Chemical cotton* (4 February 2014), <http://rodaleinstitute.org/chemical-cotton>
- 156 Environmental Justice Foundation, *The deadly chemicals in cotton* (2007), p.3
- 157 Global Fashion Agenda and Boston Consulting Group, *Pulse of the fashion industry* (2017), p.11
- 158 Water Footprint Network, *Viscose fibres production: An assessment of sustainability issues* (2017), p.22
- 159 Changing Markets Foundation, *Dirty fashion: How pollution in the textiles supply chain is making viscose toxic* (2017)
- 160 See <https://www.cdc.gov/niosh/ipcsneng/neng0360.html>
- 161 World Health Organisation, *Air quality guidelines: Carbon disulphide*, second edition (2000), pp.4-5
- 162 Changing Markets Foundation, *Dirty fashion: How pollution in the textiles supply chain is making viscose toxic* (2017)
- 163 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.17; Kirchain, R., et al., *Sustainable Apparel Materials* (2015), p.14
- 164 Hwang, K.C., *One-pot room-temperature conversion of cyclohexane to adipic acid by ozone and UV light*, Science, Vol. 346, 6216 (2014), pp.1495-1498
- 165 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.17; Greenpeace, *Hazardous chemicals in branded luxury textile products on sale during 2013* (2014), p.16
- 166 See <http://www.fibre2fashion.com/industry-article/2554/safety-and-health-issues-in-the-textile-industry?page=2>; Water Integrity Network, *Wastewater Management in the Garment Industry* (27 July 2017); Greenpeace, *Timeout for fast fashion* (2016), p.3; Greenpeace, *A little story of monstrous mess II* (2013)
- 167 KEMI, *Hazardous chemical substances in textiles* (2016), p.31; expert interview with Emma Westerholm, Officer, KEMI
- 168 KEMI, *Hazardous chemical substances in textiles: Proposals for risk management measures* (2016), p.17
- 169 Greenpeace, *Polluting paradise* (2017), <http://www.greenpeace.org/international/en/campaigns/detox/water/polluting-paradise>; Yallop, O., *Citarum, the most polluted river in the world?*, The Telegraph (11 April 2014)
- 170 Paddison, L., *The world's threatened rivers in pictures*, The Guardian (2017)
- 171 Greenpeace, *Polluting paradise* (2017), <http://www.greenpeace.org/international/en/campaigns/detox/water/polluting-paradise>
- 172 Yallop, O., *Citarum, the most polluted river in the world?*, The Telegraph (11 April 2014); Paddison, L., *The world's threatened rivers in pictures*, The Guardian (22 September 2016)
- 173 This can be for plastic microfibres as well as for microfibres that are otherwise biodegradable.
- 174 Bruce, N., et al., *Microfiber pollution and the apparel industry* (2016), p.19
- 175 Greenpeace, *Eleven hazardous chemicals which should be eliminated* (2017), <http://www.greenpeace.org/international/en/campaigns/detox/fashion/about/eleven-flagship-hazardous-chemicals>; OECD, *Synthesis paper on per- and polyfluorinated chemicals (PFCS)* (2013), p.25
- 176 Greenpeace, *Eleven hazardous chemicals which should be eliminated* (2017), <http://www.greenpeace.org/international/en/campaigns/detox/fashion/about/eleven-flagship-hazardous-chemicals>
- 177 Ibid.
- 178 See <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-nonylphenol-and-nonylphenol-ethoxylates>
- 179 Action Plan (2010), p.1; Greenpeace, *Heads in the sand over Europe's most dangerous chemicals* (2010), p.2
- 180 Environment Agency UK, *Nonylphenol ethoxylates (NPE) in imported textiles* (2013), pp.10, 21
- 181 Ibid., p.2
- 182 KEMI, *Chemicals in textiles: Risks to human health and the environment* (2014), p.52
- 183 Ibid., pp.69, 72
- 184 Ibid., p.73
- 185 Muthu, S.S., *Assessing the environmental impact of the textile and clothing supply chain* (2014); Wicker, A., *Fast fashion is creating an environmental crisis*, Newsweek (9 January 2016)
- 186 Chemsec, *Setting up an RSL/mRSL* (4 June 2017), <http://textileguide.chemsec.org/act/setting-up-an-rsl>
- 187 ECHA, *Chemicals and clothing* (2013), https://newsletter.echa.europa.eu/home/-/newsletter/entry/1_13_textile
- 188 Chemsec, *Setting up an RSL/mRSL* (4 June 2017), <http://textileguide.chemsec.org/act/setting-up-an-rsl>
- 189 MCL, *Textile standards & legislation* (2016), p.71; see <http://www.roadmaptozero.com/programme/manufacturing-restricted-substances-list-mrsl-conformity-guidance>
- 190 See <http://www.afirm-group.com>; MCL, *Textile standards & legislation* (2016), p.52
- 191 See <http://www.bciannualreport.org>
- 192 KEMI, *Hazardous chemical substances in textiles: Proposals for risk management measures* (2016), p.10
- 193 See <http://responsiblesourcing.vfc.com/chemiq>
- 194 See <https://www.bluesign.com>
- 195 MCL, *Textile standards & legislation* (2016), pp.8, 23, 71
- 196 See <https://www.greenscreenchemicals.org>; <http://www.c2ccertified.org>
- 197 Arthur, R., *From farm to finished garment: Blockchain is aiding this fashion collection with transparency*, Forbes (10 May 2017)

- 198 European Environmental Bureau, *A roadmap to revitalise REACH* (2015); Warhurst, M., *Are EU laws on chemicals – like REACH – being properly enforced?*, ChemTrust (2014); Neltner, T.G., et al., *Data gaps in toxicity testing of chemicals allowed in food in the United States* (2013); The European Chemical Industry Council, *Harmonising enforcement throughout Europe is no easy task* (2017), <http://new.cefic.org/Policy-Centre/Environment--health/REACH---Enforcement>
- 199 ECHA, *Chemicals and clothing* (2013), https://newsletter.echa.europa.eu/home/-/newsletter/entry/1_13_textile
- 200 ENDS Europe, *Countries agree textile chemical ban* (2015)
- 201 Chemsec, *The bigger picture: Assessing economic aspects of chemicals substitution* (2016)
- 202 Lovell, T., *Euratex calls for improvements to REACH restriction process*, Chemical Watch (22 February 2017)
- 203 See http://ec.europa.eu/environment/gpp/index_en.htm
- 204 European Commission, *GPP Green Procurement; a collection of good practices*, (2012), pp.17-18
- 205 EcoTextile, *Huntsman and Viyellatex enter collaboration* (2016), <https://www.ecotextile.com/2016120922485/dyes-chemicals-news/huntsman-and-viyellatex-enter-collaboration.html>
- 206 See <http://www.archroma.com/news-releases/april-13-2016-archroma-to-showcase-innovative-solutions-for-enhanced-color-performance-and-sustainability-at-china-interdye-2016-in-shanghai>
- 207 See <https://www.beyondst.com/midori-evopel>; <https://www.snewsnet.com/news/patagonias-1-million-bet-on-eco-friendly-water-repellency>
- 208 See http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=SEACOLORS_2nd_Newsletter.pdf; <http://blondandbieber.com/algaemy-textiles>
- 209 See <https://marketplace.chemsec.org>
- 210 See <http://gateway.roadmaptozero.com>
- 211 Fashion For Good, *C2C Certified 'how-to' guide* (2017), p.3
- 212 See <http://www.c-and-a.com/uk/en/corporate/company/materials>
- 213 The C2C Certified material health methodology supports manufacturers to assess inputs throughout the supply chain for toxicity, identify ways to optimise chemicals used in products, and provide third-party verification of any claims on product safety. The aspiration of C2C is that all toxic and undefined chemicals (where risks are unknown) are eliminated to make materials suitable for safe, continuous cycling. There are five levels of achievement for materials health: basic, bronze, silver, gold, and platinum. Basic means that no banned list chemicals can be used, and that all ingredients used must be known. Gold achievement is the second highest rating and means that all ingredients are assessed against the C2C rating methodology, and all are acceptable for use in the product, meaning that none of the ingredients cause highly problematic properties in the materials (see <http://www.c2ccertified.org/get-certified/levels>).
- 214 Even in products labelled with 100% cotton, these components are often made from other materials due to lower cost or superior properties of other materials
- 215 See <http://www.dystar.com/cradle-cradle>
- 216 See <http://www.c-and-a.com/uk/en/corporate/company/materials>
- 217 Piccinini, P., et al., *European survey on the release of formaldehyde from textiles* (2007)
- 218 Chemical Watch, *Euratex calls for improvements to REACH restriction process* (2017)
- 219 Patagonia, *Our DWR problem [updated]* (2016), <http://www.patagonia.com/blog/2015/09/our-dwr-problem-updated>
- 220 Maxwell, D., et al., *State of the apparel sector report: Water*, GLASA (2015)
- 221 SYSTEMIQ, Ellen MacArthur Foundation, and SUN, *Achieving Growth Within* (2017), p.80
- 222 See <http://regenerationinternational.org/why-regenerative-agriculture>
- 223 Environmental Justice Foundation, *The deadly chemicals in cotton* (2007)
- 224 Pesticide Action Network UK, *The chemical trap* (2007); <http://regenerationinternational.org/why-regenerative-agriculture>; <http://www.pan-uk.org/cotton>
- 225 SYSTEMIQ, Ellen MacArthur Foundation, and SUN, *Achieving Growth Within* (2017), p.81
- 226 Not accounting for cotton that is grown organically without certification
- 227 Dodd, N. and Caldas, M.G., *Revision of the EU Green Public Procurement criteria for textile products and services* (2017), p.22; see <http://www.bciannualreport.org>; <http://bettercotton.org>
- 228 CottonConnect, *Planting the seed: the role of organic in creating a sustainable cotton supply chain* (2017), p.3
- 229 See <http://www.cottonmadeinafrica.org/en/about-us/the-initiative>
- 230 See <http://bettercotton.org>
- 231 See <http://www.cottonedon.org>
- 232 International Union for Conservation of Nature, *Primary microplastics in the oceans: A global evaluation of sources* (2017), p.8
- 233 Thevenon, F., et al., *Plastic debris in the oceans: The characterization of marine plastics and their environmental impacts – Situation analysis report* (2014), p.19; Andrady, A.L., *Microplastics in the marine environment* Marine Pollution Bulletin, Vol. 62, 8 (2011), p.1597; Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), *Sources, fate and effects of microplastics in the marine environment: A global assessment* (2015), p.18
- 234 Browne, M.A., et al., *Accumulation of microplastic on shorelines worldwide: Sources and sinks*, Environmental Science and Technology, Vol. 45, 21 (2011), pp. 9175-9179; Bruce, N., et al., *Microfiber pollution and the apparel industry* (2015)
- 235 International Union for Conservation of Nature, *Primary microplastics in the oceans: A global evaluation of sources* (2017), p.8
- 236 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), *Sources, fate and effects of microplastics in the marine environment: A global assessment* (2015), p.17
- 237 Bruce, N., et al., *Microfiber pollution and the apparel industry* (2016)
- 238 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), *Sources, fate and effects of microplastics in the marine environment: A global assessment* (2015), p.9
- 239 World Economic Forum, Ellen MacArthur Foundation, and McKinsey & Company, *The New Plastics Economy – Rethinking the future of plastics* (2016), p.17

- 240 Thevenon, F., et al., *Plastic debris in the oceans: The characterization of marine plastics and their environmental impacts – Situation analysis report* (2014), p.43
- 241 Watts, A.J.R., et al., *Ingestion of plastic microfibers by the crab *Carcinus maenas* and its effect on food consumption and energy balance* (2015); Eriksen, M., et al., *Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea* (2014)
- 242 Van Cauwenberghe, L., and Janssen, C. R., *Microplastics in bivalves cultured for human consumption*, Environmental Pollution Vol. 193 (2014), p.65
- 243 Liebezeit, G. and Liebezeit, E., *Synthetic particles as contaminants in German beers*, Food Additives & Contaminants: Part A (2014), pp.1574–1578; Liebezeit, G. and Liebezeit, E., *Non-pollen particulates in honey and sugar*, Food Additives & Contaminants: Part A (2013), pp.2136–2140; Bruce, N., et al., *Microfiber pollution and the apparel industry* (2016), p.20
- 244 International Union for Conservation of Nature, *Primary microplastics in the oceans: A global evaluation of sources* (2017), p.20
- 245 Reed, C., *Plastic Age: How it's reshaping rocks, oceans and life*, New Scientist (28 January 2015)
- 246 See <https://www.plasticsoupfoundation.org>
- 247 O'Connor, M.C., *Inside the lonely fight against the biggest environmental problem you've never heard of*, The Guardian (27 October 2014)
- 248 Browne, M.A., et al., *Accumulation of microplastic on shorelines worldwide: Sources and sinks*, Environmental Science and Technology, Vol. 45, 21 (2011), pp.9175–9179
- 249 International Union for Conservation of Nature, *Primary microplastics in the oceans: A global evaluation of sources* (2017), p.21
- 250 For example, estimates for microfibre losses from washing a single garment are stated in one report at around 2,000 fibres (Browne, M.A., et al., *Accumulation of microplastic on shorelines worldwide: Sources and sinks*, Environmental Science and Technology, Vol. 45, 21 (2011), pp.9175–9179), whereas another reported a range between 8,500 and 250,000 fibres lost (Bruce, N., et al., *Microfiber masses recovered from conventional machine washing of new or aged garments* (2016)).
- 251 Leonard, G.H., *Oceans, microfibers and the outdoor industry: A leadership opportunity. Presentation to Outdoor Industry Association* (2016)
- 252 Based on the central scenario in International Union for Conservation of Nature, *Primary microplastics in the oceans: A global evaluation of sources* (2017), p.20. Their analysis is based on two different approaches, one based on the estimated number of wash cycles per region, the other based on global textile sales, which come to similar results (see p.34 in their study). A separate Circular Fibres Initiative analysis led to similar results. Another study for the EU Commission (Eunomia Research & Consulting Ltd., *Study to support the development of measures to combat a range of marine litter sources*, report for DG Environment of the European Commission (2016), p.272 ff.) estimates 30,000 tonnes per year in Europe alone.
- 253 Assuming 180 grams for an average top
- 254 Bruce, N., et al., *Microfiber pollution and the apparel industry* (2016), pp.8–9
- 255 Ibid., p.10
- 256 Ibid.; Taylor, M.L., et al., *Plastic microfibre ingestion by deep-sea organisms* (2016)
- 257 Patagonia, *The cleanest line: An update on microfibre pollution* (2017), <http://www.patagonia.com/blog/2017/02/an-update-on-microfiber-pollution/>
- 258 O'Connor, M.C., *Will clothes companies do the right thing to reduce microfibre pollution?*, The Guardian (13 May 2017)
- 259 Mermaids Consortium, *Position paper: Microfiber release from clothes after washing* (2017)
- 260 Roos, S., et al, *Microplastics shedding from polyester fabrics*, Mistra Future Fashion (2017)
- 261 Outdoor Industry Association, *Microfibres and the outdoor industry: Issue update* (2017), <https://outdoorindustry.org/article/microfibers-and-the-outdoor-industry-issue-update>
- 262 See <http://www.europeanoutdoorgroup.com/news/outdoor-industry-microfibre-consortium-formed>
- 263 Napper, I.E. and Thompson, R.C., *Release of synthetic microplastic plastic fibres from domestic washing machines: Effects of fabric type and washing conditions* (2016)
- 264 See <https://crowd.science/campaigns/dont-feed-the-fish>
- 265 Roos, S., et al., *Microplastics shedding from polyester fabrics*, Mistra Future Fashion (2017), p.1
- 266 See <http://life-mermaids.eu/en>
- 267 Mermaids Consortium, *Handbook for zero microplastics from textiles and laundry* (2016), p.3, <http://life-mermaids.eu/en/deliverables-mermaids-life-2>
- 268 Ibid., p.7
- 269 Bruce, N., et al., *Microfiber pollution and the apparel industry* (2016), p.3
- 270 See <http://guppyfriend.com>
- 271 See <http://coraball.com>
- 272 See <http://www.septicsafe.com/filtrol-160-lint-filter-with-1-filter-bag>
- 273 Patagonia, *The cleanest line: An update on microfibre pollution* (2017), <http://www.patagonia.com/blog/2017/02/an-update-on-microfiber-pollution>
- 274 See <http://rozaliaproject.org/stop-microfiber-pollution>
- 275 See <https://www.outsideonline.com/2091876/patagonias-new-study-finds-fleece-jackets-are-serious-pollutant>
- 276 Mermaids Consortium, *Mitigation of microplastics impact caused by textile washing processes: Policy recommendations based on actions A and B* (2016), p.18
- 277 Zubris, K.A.V. and Richards, B.K., *Synthetic fibers as an indicator of land application of sludge* (2005)
- 278 Mermaids Consortium, *Policy recommendations based on actions A and B* (2017), p.7
- 279 See https://ec.europa.eu/info/consultations/public-consultation-investigating-options-reducing-releases-environment-microplastics_en
- 280 International Union for Conservation of Nature, *Primary microplastics in the oceans: A global evaluation of sources* (2017), p.21
- 281 See <http://storyofstuff.org/plastic-microbeads-ban-the-bead>
- 282 Mermaids Consortium, *Position paper: Microfiber release from clothes after washing* (2017), p.4

- 283 Calculation of the GHG emissions avoided from the production phase based on Circular Fibres Initiative externalities analysis (for details see Appendix B), and assuming second-hand operations consume ten times less energy than the production of clothing (based on Laursen, S.E., *Sustainable recovery of products and materials: Scenario analysis of the UK clothing and textile sector* (2005), p.8).
- 284 Calculation based on Circular Fibres Initiative materials flow analysis (for details see Appendix B), and Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005–2015). In 2015, 46% (in mass) of collected garments were reused. If 100% of discarded clothing were collected, 22.2 million tonnes would be reused instead of 5.6 million tonnes as at present, meaning 16.6 million tonnes of new garment sales would be avoided, with a value of USD 460 billion.
- 285 Cambridge Dictionary definition: “the act of buying special things for yourself in order to feel better when you are unhappy”
- 286 Greenpeace, *After the binge, the hangover: Insights into the minds of clothing consumers* (2017)
- 287 Bocken, N.M.P., et al., *Product design and business model strategies for a circular economy*, Journal of Industrial and Production Engineering, Vol. 33, 5 (2015), pp.308–320
- 288 Shaw, D. and Koumbis, D., *Fashion buying: From trend forecasting to shop floor* (2013), p.126
- 289 WRAP, *SCAP textiles tracker survey* (2016); Armstrong, C.M., *A use-oriented clothing economy? Preliminary affirmation for sustainable clothing consumption alternatives* (2016), p.27; Nielsen, K.S. and Gwozdz, W., *Field report: Consumer survey*, Mistra Future Fashion (2017), p.17
- 290 WRAP, *SCAP textiles tracker survey* (2016)
- 291 Shwe Gaung, J., *YCloset raises Series B \$20m from Pan-Lin Asset*, IDG, Deal Street Asia (20 March 2017)
- 292 Cision PR Newswire, *Rent the Runway raises \$60 Million in Series E funding led by Fidelity Investments* (27 December 2016)
- 293 McBride, S., *Bricks-and-mortar shops bet on startup tech to bring back customers*, Bloomberg Businessweek (9 February 2017)
- 294 Kumar, A., et al., *Waiting for Merlot: Anticipatory consumption of experiential and material purchases*, Psychological Science, Vol. 25, 10 (2014); Morgan, B., *NOwnership, no problem: Why millennials value experiences over owning things*, Forbes (1 June 2015)
- 295 Goldman Sachs, *Millennials coming of age* (2017), <http://www.goldmansachs.com/our-thinking/pages/millennials/>
- 296 Business of Fashion and McKinsey & Company, *The State of Fashion 2017* (2017), p.25
- 297 Expert interview with Doris Ke, Head of Marketing, YCloset
- 298 Nielsen, K. S. and Gwozdz, W., *Field report: Consumer survey*, Mistra Future Fashion (2017), p.17
- 299 See <http://www.mysubscriptionaddiction.com>; Segran, E., *From socks to sex toys: Inside America's subscription-box obsession*, Fast Company (4 June 2015)
- 300 Catulli, M., et al., *Consuming use-orientated product service systems: A consumer culture theory perspective*, Journal of Cleaner Production, Vol. 141 (2017)
- 301 Expert interview with Colin Strong, Global Head of Behavioural Science, Ipsos
- 302 Eytan, D., *Are fashion bloggers able to convert followers into buyers?*, Forbes (11 May 2016)
- 303 Expert interview with Peter Svensson, Vigga co-founder
- 304 Goldmark, A., *Can anyone make a 'Netflix for baby clothes' work?*, GOOD (1 March 2012)
- 305 See <https://borrowforyourbump.com>
- 306 Vasan, P., *Rent the Runway's designer closet tops \$800 million*, CNBC (25 July 2015)
- 307 Shwe Gaung, J., *YCloset raises Series B \$20m from Pan-Lin Asset*, IDG, Deal Street Asia (20 March 2017)
- 308 Esposito, M., et al., *Reverse logistics for postal services within a circular economy* (2017)
- 309 Meenhorst, E., *Building an optimized return solution from logistic network commodities*, Reverse Logistics Magazine (2008)
- 310 Expert interview with Peter Svensson, Vigga co-founder
- 311 Joerss, M., et al., *How customer demands are reshaping last-mile delivery*, McKinsey Quarterly (2016)
- 312 PWC, *Shifting patterns: The future of the logistics industry* (2016), p.22
- 313 Wang, U., *How the Netflix model impacts the environment, economy and society*, The Guardian (6 February 2014)
- 314 See <http://letote.zendesk.com>
- 315 See <https://help.renttherunway.com/hc/en-us/articles/212479018-How-does-Rent-the-Runway-work->
- 316 Ma, A., et al., *Alibaba logistics arm reaches out for parcel locker buy-in*, Caixin Global (12 June 2017)
- 317 Green, C., *Clothing rental: New subscription service allows customers to rent clothes from high street shops*, The Independent (9 February 2016)
- 318 See <https://www.renttherunway.com/stories/nycflagship>
- 319 Niinimäki, K. and Hassi, L., *Emerging design strategies in sustainable production and consumption of textiles and clothing*, Journal of Cleaner Production, Vol. 19 (2011), p.1879
- 320 Ibid.
- 321 Euromonitor International Apparel & Footwear 2016 Edition (volume sales trends 2005–2015)
- 322 WRAP, *Clothing longevity protocol* (2014), p.1
- 323 MacKinnon, J.B., *Patagonia's anti-growth strategy*, The New Yorker (21 May 2015)
- 324 Koppelman, C., *5 reasons why American Giant is the new Levi Strauss: Back to basics on American basics*, Forbes (14 February 2017)
- 325 See <https://www.yotpo.com/blog/5-brands-with-an-unlimited-lifetime-guarantee>
- 326 See <http://www.patagonia.com/ironclad-guarantee.html>
- 327 SGS, *End customers perspective on policies and extended warranties* (2016)
- 328 WRAP, *Scale and nature of corporate-wear arisings and market opportunities* (2012)
- 329 WRAP, *Valuing our clothes* (2012), p.5
- 330 FinanCE Working Group, *Money makes the world go round* (2016), <http://www.circle-economy.com/moneymaketheworldgoround>
- 331 See <http://www.mudjeans.eu>
- 332 Expert interview with Bert Van Son, CEO of MUD Jeans
- 333 Jonathan Chapman, *Emotionally Durable Design: Objects, Experiences and Empathy* (2005)
- 334 Fletcher, K., *Sustainable fashion and textiles: Design journeys*, second edition (2014), p.222

- 335 The Telegraph, *The tailor-made tourist* (11 March 2003); Afua Hirsch, *Why Ghana is ahead of the curve*, The Guardian (4 August 2013)
- 336 Decker, V., *With \$10.2 million in funding, Nyree Corby's Fame and Partners is aiming to be the anti-fashion brand*, Forbes (14 May 2017)
- 337 See <http://www.postcouture.cc>
- 338 Ibid., p.156
- 339 Connor-Crabb, A., et al., *Design strategies for the eternal reoccurrence of the new* (2016), p.33
- 340 See <http://petitpli.com>
- 341 See <http://cutecircuit.com>
- 342 Circular Fibres Initiative analysis – for details see Appendix B
- 343 ThredUp, *5th annual resale report* (2017), p.1
- 344 McKinsey & Company, *Why every leader should care about digitization and disruptive innovation* (6 July 2017), <http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/why-every-leader-should-care-about-digitization-and-disruptive-innovation>
- 345 Forbes, *Fashion retailers have to adapt to deal with second-hand clothes sold online* (11 April 2017)
- 346 ThredUp, *5th annual resale report* (2017), p.13
- 347 See <https://www.therealreal.com>; <https://www.thredup.com>; <https://www.vestiairecollective.com>; <https://www.freecycle.org>
- 348 See <https://www.patagonia.com.au/pages/worn-wear>
- 349 Hvass, K.K., *Business model innovation through second-hand retailing: A fashion industry case* (2015), p.24
- 350 See: <https://fashionista.com/2017/10/stella-mccartney-the-realreal-partnership>
- 351 Hvass, K.K., *Post-retail responsibility of garments: A fashion industry perspective* (2013), p.15
- 352 See <https://www.yerdle.com/>
- 353 Case study box based on an expert interview with Nicole Bassett, Co-founder of The Renewal Workshop, and the website <https://renewalworkshop.com>
- 354 WRAP, *Evaluating the financial viability and resource implications for new business models in the clothing sector* (2013), p.2
- 355 Greenpeace, *Fashion at the crossroads* (2017), p.23
- 356 See <https://www.patagonia.com.au/pages/worn-wear>; Patagonia, *The cleanest line: Extended play* (2017), <https://www.patagonia.com/blog/2017/09/extended-play>
- 357 Sustainable Brands, *H&M's clever care labels helping customers extend clothing life while saving energy, water* (30 April 2014)
- 358 NXP, *Smart clothing: The next big thing in IoT wearables?* (15 February 2016), <https://blog.nxp.com/portable-wearable/smart-clothing-iot-wearables>
- 359 See <https://www.khongboonswimwear.com/nfc-technology>
- 360 See <https://www.patagonia.com.au/pages/worn-wear>
- 361 Hindle, T., *Planned obsolescence*, The Economist (23 March 2009)
- 362 See <http://ddm.higg.org/page/ddm-home>
- 363 WRAP, *Clothing longevity protocol* (2014)
- 364 See <http://designforlongevity.com>
- 365 WRAP, *Sustainable clothing: A practical guide to enhancing clothing quality and durability* (2017)
- 366 Legifrance, *Code de l'environnement: Article L541-10-3*
- 367 Elander, M., et al., *Impact assessment of policies promoting fiber-to-fiber recycling of textiles (short abstract)*, *Mistra Future Fashion* (2017), p.8
- 368 See <http://www.ecotlc.fr/page-335-l-eco-conception.html>
- 369 PRI, *Sweden tries to curb buy-and-throw-away culture through tax breaks* (2 January 2017)
- 370 As clothing is the focus of this report, the term 'clothing-to-clothing recycling' is used in this chapter. The types of recycling discussed here can also be used for other types of textiles, both at source and destination, and there is usually no need to limit those technologies to clothing-to-clothing (and often it would be impractical). However, existing technologies to downcycle used textiles into low-value applications, such as cleaning cloths or stuffing could be seen as textile-to-textile recycling, which is why this term is avoided. The recycling technologies discussed here (see Box J), with the exception of fabric recycling and yarn recycling, are also often referred to as 'fibre-to-fibre recycling' (see, e.g. WRAP, *Evaluation of the end markets for textile rag and fibre within the UK* (2014), p.3; Global Fashion Agenda and The Boston Consulting Group, *Pulse of the fashion industry* (2017), p.76).
- 371 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.42
- 372 Estimate based on Circular Fibres Initiative analysis on the share of materials and on a price of USD 2.8/kg for cotton yarn and USD 1.7/kg for polyester yarn (see <http://www.globaltexassociates.com/price.html>).
- 373 See <http://mistrafuturefashion.com/sustainable-fashion>
- 374 See <http://nordicfashionassociation.com/content/recycling-and-waste-0>
- 375 Goldsworthy, K., *Mistra Future Fashion report: Design for cyclability* (2014)
- 376 Oakdene Hollins, *Closed loop fibre recycling: Current status and future challenges* (2013); Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.118; see <http://mistrafuturefashion.com/sustainable-fashion>
- 377 WRAP, *Evaluation of the end markets for textile rag and fibre within the UK* (2014), p.18; see <http://www.lmb-supplies.co.uk/recycling.html>
- 378 See <http://www.recycleaid.co.uk/cloth-and-fabric-recycling/waste-clothes-and-fabric-recycling>; <http://levistrauss.com/unzipped-blog/2014/03/denim-insulation-101-how-recycled-jeans-can-keep-you-warm>; WRAP, *Evaluation of the end markets for textile rag and fibre within the UK* (2014), p.19
- 379 Estimate of 1-3% based on McKinsey Analysis; IHS; SRI; CMAI; TECNON; expert discussion
- 380 See http://www.polygenta.com/Our_Breakthrough_process.html; <https://www.polyterra.com/en/materials>; <http://www.recovertext.com/sustainability>; <http://www.repreve.com>
- 381 See <http://www.adidas.co.uk/parley>; <http://sustainability.c-and-a.com/sustainable-products/sustainable-materials/other-raw-materials/polyester>; <http://about.hm.com/en/sustainability/sustainable-fashion/materials.html>; <https://news.nike.com/news/nike-better-world>
- 382 See <http://apparelcoalition.org/the-higg-index>
- 383 See <http://msi.higg.org/page/learn-more#what-is-the-scope-of-the-msi>
- 384 See <https://www.ftc.gov/tips-advice/business-center/guidance/calling-it-cotton-labeling-advertising-cotton-products>

- 385 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.79
- 386 See <http://www.cientifica.com/research/market-reports/smart-textiles-apparel-markets-applications-technologies>
- 387 Innovation in Textiles, *Smart textiles and wearables: Markets, application and technologies, United Kingdom* (2016)
- 388 See <http://rbis.averydennison.com/en/home/our-solutions/apparel-and-footwear-branding/introducing-janela-smart-product-platform.html>
- 389 See <https://elektrocouture.com/collections>
- 390 See <https://elektrocouture.com/portfolio/2nd-generation-inforce-yoga>
- 391 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.124; Global Fashion Agenda and The Boston Consulting Group, *Pulse of the fashion industry* (2017), p.124
- 392 See <http://trash2cashproject.eu/about>
- 393 Greenpeace, *Fashion at the Crossroads* (2017), p.81
- 394 See <https://www.circle-economy.com/textile-sorting-project>
- 395 See <http://www.fashionpositive.org/plus>
- 396 Elmogahzy, Y., *Yarn engineering*, Indian Journal of Fibre & Textile research, Vol. 31 (2006)
- 397 Singh, K., *Analysis of spandex/cotton elastomeric properties: Spinning and applications* (2012)
- 398 Muthu, S., *Sustainable fibres and textiles* (2017), p.113
- 399 See <http://www.samsoe.com/is/man/apparel/blazers-and-suits/suit-pants/laurent-pants-fold-up-6568/M00004178.html>
- 400 See http://www2.hm.com/en_gb/productpage.0519787002.html?gclid=EAlalQobChMI2djt662V1gIVsRXTChId_wO8EAQYASABEgJhFfD_BwE&skwid=AL!850!3!214282971985!!!!&ef_id=WMFvMwAABS5g4ZIM:20170908101611:s
- 401 See <http://www.textileschool.com/articles/81/sewing-thread>; <https://www.ftc.gov/tips-advice/business-center/guidance/calling-it-cotton-labeling-advertising-cotton-products>
- 402 See <https://www.wolfordshop.com/aboutwolford/Sustainability.html>
- 403 Expert interviews with Enrica Arena, Co-founder and CEO, Orange Fibre, and Annie Gullingsrud, Director, Textiles and Apparel Sector, Cradle2Cradle
- 404 This quality loss is higher for woven than for knit garments and it is also higher the tighter the garment is woven/knitted (see <http://www.threadsmagazine.com/item/5152/knits-wovens-whats-the-difference>).
- 405 Ellen MacArthur Foundation, World Economic Forum, and McKinsey & Company, *The New Plastics Economy: Rethinking the future of plastics* (2016), pp.80-81
- 406 KEMI, *Chemicals in textiles: Risks to human health and the environment* (2014)
- 407 See <https://globalchangeaward.com/winner/winner-1>
- 408 See <http://adnas.com/cotton-supply-chain-protection>
- 409 Blockchain technology is based on a distributed database not centrally owned by any one person. Any information added is stored in 'blocks' owned by a number of people. These blocks then form a chain of information to create a complete history for an item. Any attempt to change a block in retrospect will be detected by the system because the information would differ from that of all the other participants of that specific blockchain. This guarantees reliable data that is safe from fraudulent claims (see, e.g. <http://www.goldmansachs.com/our-thinking/pages/blockchain>).
- 410 See <https://www.provenance.org/case-studies/martine-jarlgaard>
- 411 Efforts to account for the costs of negative externalities in the material price (see Section 4.2) could help increase the cost-competitiveness of recycled materials.
- 412 See <http://www.nurmiclothing.com>; <https://www.thereformation.com>; <https://ahlma.cc>; <https://www.looptworks.com>
- 413 See <http://about.lindex.com/en/redesign2>
- 414 See <https://www.uschamberfoundation.org/eileen-fisher-s-intuitive-journey-circularity>
- 415 See <http://www.ctechinnovation.com/funded-projects/wear2-microwave-textile-disassembly>
- 416 Greenstrategy, *Introducing the concept 'single-thread knitwear'* (20 October 2016),
- 417 See <http://www.greenstrategy.se/introducing-the-concept-single-thread-knitwear>
- 418 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.42
- 419 See <http://www.3cfilati.it/en/portfolios/cardato-recycled-by-3c-filati>
- 420 See <https://about.hm.com/en/sustainability/get-involved/recycle-your-clothes.html>; Hilaturas Ferre, *Certificate of compliance* (2016)
- 421 See <https://about.hm.com/en/sustainability/get-involved/recycle-your-clothes.html>
- 422 See <https://www.ellenmacarthurfoundation.org/case-studies/pioneering-a-lease-model-for-organic-cotton-jeans>
- 423 Palme, A., et al., *Cellulose: Chemical and ultrastructural changes in cotton cellulose induced by laundering and textile use*, Cellulose, Vol. 21, 6 (2014), p.4681
- 424 Hilaturas Ferre, *Certificate of compliance* (2016)
- 425 Williams, M., *Deutsche Welle: Italian fabric makers turn dirty secret into marketing weapon* (24 December 2010)
- 426 See <http://www.wolkat.com/en>; <http://www.geetanjaliwoollens.com>
- 427 See <http://www.cardato.it/en/brand-cardato-recycled>
- 428 See <http://www.3cfilati.it/en/portfolios/cardato-recycled-by-3c-filati>
- 429 See <http://dutchawearness.com/chainmanagement>
- 430 Palme, A., et al., *Cellulose: Chemical and ultrastructural changes in cotton cellulose induced by laundering and textile use*, Cellulose, Vol. 21, 6 (2014), p.4681
- 431 See <http://www.lenzing-fibers.com/en/tencel/refibra>
- 432 See <http://renewcell.se>; <http://infinitefiber.com/strategy-2>
- 433 See <http://www.evrnu.com/technology>; <http://www.levistrauss.com/unzipped-blog/2016/05/levi-strauss-co-evrnu-create-first-pair-of-jeans-from-post-consumer-cotton-waste>; <https://www.apparelnews.net/news/2016/dec/08/evrnu-regenerated-cotton-sustainable-second-time-a>

- 434 Expert interview with Cyndi Rhoades, Founder and CEO, Worn Again
- 435 H&M Foundation, *Technological breakthrough: Successful method found for recycling blend textiles into new fibres* (11 September 2017), <http://hmfoundation.com/news/technological-breakthrough-successful-method-found-for-recycling-blend-textiles-into-new-fibres>
- 436 Achilias, D., et al., *Recent advances in chemical recycling of polymers (PP, PS, LDPE, HDPE, PVC, PC, Nylon, PMMA), material recycling: Trends and perspectives* (2012)
- 437 See <http://www2.teijin-frontier.com/english/sozai/specifics/ecopet-plus.html>; <http://www.econyl.com/regeneration-system/>
- 438 See http://www.resyntex.eu/images/downloads/RESYNTEX_Introduction_Presentation_2016.pdf
- 439 See <https://www.aquafil.com/sustainability/econyl>
- 440 See <http://www2.teijin-frontier.com/english/sozai/specifics/eco-circle.html>
- 441 Patagonia, *Closing the loop: A report on Patagonia's Common Threads garment recycling program* (7 July 2009), <http://www.patagonia.com/blog/2009/03/closing-the-loop-a-report-on-patagonias-common-threads-garment-recycling-program>
- 442 Global Fashion Agenda and The Boston Consulting Group, *Pulse of the fashion industry* (2017), p.44
- 443 See https://www.jeplan.co.jp/en/technology/polyester_recycle
- 444 See <http://www.ioniqa.com/company/>; expert interview with Tonnis Hooghoudt, CEO, Ioniqa
- 445 WRAP, *Technologies for sorting end of life textiles* (2014)
- 446 Expert interview with Lucie Ackermann, Project Manager, Valvan
- 447 See <http://www.valvan.com/uncategorized/introducing-the-fibersort>
- 448 See http://www.valvan.com/wp-content/uploads/2015/10/Valvan-leaflet-FIBERSORT_LR.pdf
- 449 See <https://www.circle-economy.com/a-key-enabler-for-high-value-textile-to-textile-recycling-is-on-its-way-to-the-market>
- 450 Blanch-Perez-del-Notario, C. and Lambrechts, A., *Hyperspectral imaging for textile sorting and recycling in industry* (2016)
- 451 See <http://www.ivl.se/english/startpage/top-menu/pressroom/press-releases/press-releases---arkiv/2017-03-28-new-technology-may-revolutionize-textile-recycling.html>; expert interview with Maria Elander, Project Lead, SIPTex
- 452 Global Fashion Agenda, *A call to action for a circular fashion system* (2017)
- 453 H&M, *Sustainability report* (2016)
- 454 C&A, *Global sustainability report* (2016)
- 455 See <http://www.kering.com/en/sustainability/2025-strategy/care>
- 456 See https://ec.europa.eu/growth/single-market/public-procurement_en
- 457 See <http://www.ecap.eu.com/action-plan/public-procurement-action>
- 458 Ibid.
- 459 See <http://www.rebus.eu.com/wp-content/uploads/2017/05/ECAP-Workwear-Report.pdf>
- 460 Dutch Enterprise Agency, *Criteria for sustainable procurement of workwear* (2011), <http://english.rvo.nl/sites/default/files/2013/12/Criteriadocument%20Workwear.pdf>
- 461 European Commission, *Reusing workwear in Herring*, GPP in practice, 65 (2016)
- 462 See <http://www.oecd.org/env/tools-evaluation/extendedproducerresponsibility.htm>
- 463 See <http://www.ecotlc.fr/page-297-information-in-english.html>
- 464 See http://europa.eu/rapid/press-release_MEMO-15-6204_en.htm
- 465 See <http://www.greenpeace.org/international/Global/international/briefings/toxics/2016/Fact-Sheet-Timeout-for-fast-fashion.pdf>
- 466 See <https://www.reuters.com/article/china-environment/china-notifies-wto-of-ban-on-plastic-paper-textile-waste-imports-idUSL5N1K94IS>
- 467 Expert interview with Helene Smits, Brand Manager, Recover, and Deepak Goel, CEO, Geetanjali
- 468 Expert interviews with representatives from Recover, ReBlend, Wolkat, and Geetanjali
- 469 See <http://textileexchange.org/wp-content/uploads/2017/06/Global-Recycled-Standard-v4.0.pdf>
- 470 See <http://textileexchange.org/wp-content/uploads/2017/06/Recycled-Claim-Standard-v2.0.pdf>
- 471 See <http://www.circle-economy.com/case/circle-market/#.WallYNOGORT>; <http://www.netherlandscircularchotspot.nl/circle-market.html>
- 472 See <http://www.hm.charitystar.com>
- 473 See <http://simplerecycling.com>; see http://www.wrap.org.uk/sites/files/wrap/Textiles_Guide_CS_Bexley_0.pdf <https://www.iwight.com/Residents/Waste-and-Recycling/Household-Waste-and-Recycling-Collection/Other-Collection-Services>; see http://europe.chinadaily.com.cn/china/2017-08/30/content_31308134.htm
- 474 See <https://www.bhf.org.uk/shop/donating-goods/free-collection-of-clothes-books-and-more>
- 475 See <https://www.drk.de/spenden/spenderservice/spendentransparenz/kleidersammlung>
- 476 See <https://www.texaid.ch/en/products-and-services/collection/container-collection.html>
- 477 Nationswell, *Old clothes are getting kicked to the curb in this city (but it's a good thing)* (17 January 2014)
- 478 See <http://www.patagonia.com/recycling.html>
- 479 See <https://www.fisherfound.com>
- 480 See <https://about.hm.com/en/sustainability/get-involved/recycle-your-clothes.html>
- 481 See <https://www.zara.com/uk/en/info/join-life/clothes-collecting-c861007.html>
- 482 See <http://www.oxfam.org.uk/donate/donate-goods>
- 483 See <http://www.redcross.org.uk/en/Get-involved/Our-shops/Donate-to-our-charity-shops>
- 484 See <https://www.bhf.org.uk/shop/donating-goods/free-collection-of-clothes-books-and-more>
- 485 Circular Fibres Initiative analysis – for details see Appendix B
- 486 Ibid.
- 487 Rodgers, L., *Where do your old clothes go?*, BBC (11 February 2015), <http://www.bbc.co.uk/news/magazine-30227025>

- 488 Watson, D., et al., *Exports of Nordic used textiles: Fate, benefits and impacts* (2016), p.67; United Nations, *Comtrade Database* (2013)
- 489 TradeMark East Africa, *A second-hand clothing ban in East Africa?* (18 May 2016), <https://www.trademarkea.com/news/a-second-hand-clothing-ban-in-east-africa>
- 490 Watson, D., et al., *Exports of Nordic used textiles: Fate, benefits and impacts* (2016), p.121
- 491 Ibid., p.5
- 492 WRAP, *Textiles market situation report* (2016), p.8
- 493 See <http://www.ico-spirit.com/en/company>; <https://about.hm.com/en/sustainability/get-involved/recycle-your-clothes.html>
- 494 KEMI, *Chemicals in textiles: Risks to human health and the environment* (2014), p.33
- 495 Saxena, S., et al., *Challenges in sustainable wet processing of textiles* (2017); based on a price of USD 5,000 per tonne of reactive dye; prices on Alibaba (5 July 2017)
- 496 Eunomia, *The potential contribution of waste management to a low carbon economy* (2015)
- 497 Kirchain, R., et al., *Sustainable apparel materials* (2015), p.17
- 498 Turley, D.B., et al., *The role and business case for existing and emerging fibres in sustainable clothing: Final report to the Department for Environment, Food and Rural Affairs (Defra)* (2010)
- 499 World Economic Forum, Ellen MacArthur Foundation, and McKinsey & Company, *The New Plastics Economy: Rethinking the future of plastics* (2015)
- 500 White, G., *Cotton price causes 'panic buying' as nears 150-year high*, *The Telegraph* (2011)
- 501 Euromonitor International Apparel, Footwear, & Accessories 2016 Edition (brand shares 2000-2015)
- 502 See <https://www.ers.usda.gov/topics/international-markets-trade/global-food-markets/global-food-industry>
- 503 See <http://manufacturingmap.nikeinc.com>
- 504 Fast Retailing, *Annual report 2016* (2017), http://www.fastretailing.com/eng/ir/library/pdf/ar2016_en.pdf
- 505 Maxwell, D., et al., *State of the apparel sector report: Water*, GLASA (2015), p.31
- 506 IDH and True Price, *The true price of cotton from India* (2016), p.15
- 507 See <http://about.puma.com/en/sustainability/environment/environmental-profit-and-loss-account>
- 508 Kering, *Environmental Profit and Loss: 2015 group results* (2015), p.7; Kering, *Sustainability Targets report* (2016) pp.55-57
- 509 See <http://www.kering.com/en/sustainability/motivation>
- 510 See <http://naturalcapitalcoalition.org/protocol>
- 511 Natural Capital Coalition, *Apparel sector guide* (2016)
- 512 See <http://apparelcoalition.org/the-higg-index>; <http://www.made-by.org/consultancy/tools/environmental>
- 513 World Economic Forum, Ellen MacArthur Foundation, and McKinsey & Company, *The New Plastics Economy: Rethinking the future of plastics* (2015), p.92
- 514 Changing Markets Foundation, *Dirty fashion: How pollution in the textiles supply chain is making viscose toxic* (2017)
- 515 See <http://www.canopystyle.org/forests>
- 516 See <http://orangefiber.it>
- 517 See <http://www.qmilk.eu>
- 518 Sustainable Brands, *Plug and play accelerator reveals 12 new startups changing the face of fashion* (19 April 2017)
- 519 See https://ecoalf.com/uk_en/about/processes/coffee-grounds
- 520 See <http://www.biosteel-fiber.com/home/#c243>; <https://boltthreads.com>; http://www.tjeerdveenhoven.com/portfolio_page/algaefabrics
- 521 See <http://orangefiber.it/en/collections>
- 522 See <https://www.nytimes.com/2017/11/12/style/alternative-fabrics-sustainability-recycling.html>
- 523 See <https://fashionforgood.com>
- 524 See Appendix B
- 525 Reverse Resources, *The Undiscovered Business Potential of Production Leftovers within Global Fashion Supply Chains: Creating a Digitally Enhanced Circular Economy* (2017), p.6
- 526 See <http://nordicfashionassociation.com/content/waste-production-phase>; Reverse Resources, *The Undiscovered Business Potential of Production Leftovers within Global Fashion Supply Chains: Creating a Digitally Enhanced Circular Economy* (2017), p.6
- 527 Reverse Resources, *The undiscovered business potential of production leftovers within global fashion supply chains: creating a digitally enhanced circular economy* (2017), pp.9-10
- 528 Ibid., p.30
- 529 Ibid., pp.13-14
- 530 Ibid., p.15
- 531 Ibid., p.30
- 532 Global Fashion Agenda and The Boston Consulting Group, *The Pulse of the fashion industry* (2017)
- 533 NRDC, *NRDC's 10 best practices for textile mills to save money and reduce pollution* (2013), p.5
- 534 Hasanbeigi, A., *Energy efficiency improvement opportunities for the textile industry* (2010), p.28
- 535 GLASA, *The state of the apparel sector* (2015)
- 536 MakingIt Magazine, *Good business: Viyellatex* (2012)
- 537 Ibid.
- 538 Ibid.
- 539 Viyellatex, *Corporate sustainability report* (2011)
- 540 Viyellatex, *Corporate sustainability report* (2012)
- 541 Hasanbeigi, A. and Price, L., *Price review of energy use and energy efficiency technologies for the textile industry* (2012)
- 542 See <http://www.em2m.eu>
- 543 Porteous, A. and Rammohan, S., *Integration, incentives and innovation: Nike's strategy to improve social and environmental conditions in its global supply chain* (2013)
- 544 See <http://about.nike.com/pages/transform-manufacturing>
- 545 Green Supply Chain, *Green Supply Chain news: Nike promises revolution in its approach to manufacturing* (2016)
- 546 Porteous, A. and Rammohan, S., *Integration, incentives and innovation: Nike's strategy to improve social and environmental conditions in its global supply chain* (2013)
- 547 Clean by Design, *Fibre selection: Understanding the impact of different fibers is the first step in designing environmentally responsible apparel* (2012)

- 548 See <http://www.lenzing-fibers.com/en/tencel>
- 549 Maxwell, D., et al., *State of the apparel sector report: Water*, GLASA (2015), p.36
- 550 Ibid., p.37
- 551 Ibid., p.37
- 552 Ibid., p.38
- 553 Hepburn, S., *Nike and Adidas show cautious support for eco-friendly dye technology*, The Guardian (24 April 2015)
- 554 Ethridge, D., *Policy-driven causes for cotton's decreasing market share of fibers* (2016), p.2
- 555 Textile Exchange, *Preferred fiber market report* (2016), p.55
- 556 FAO, *World apparel fibre consumption survey* (2013), p.2
- 557 Textile Exchange, *Preferred fiber market report* (2016), p.7
- 558 Muthu, S., *Sustainable fibres and textiles* (2017) p.281
- 559 See <http://www.uniformreuse.co.uk/alternative-fabric.php?textile=4>
- 560 See <http://www.fibersource.com/fiber-products>
- 561 See <http://www.bbc.co.uk/schools/gcsebitesize/design/textiles/fibresrev4.shtml>
- 562 Clean by Design, *Fibre selection* (2012)
- 563 Quartz, *If your clothes aren't already made of plastic, they will be* (5 June 2015); Turley, D.B., et al., *The role and business case for existing and emerging fibres in sustainable clothing: Final report to the Department for Environment, Food and Rural Affairs (Defra)* (2010); see <http://fibersource.wpengine.com/fiber-products/polyester-fiber>
- 564 Greenpeace, *Hazardous chemicals in branded luxury textile products on sale during 2013* (2014), p.17; Shotyk, W., et al., *Contamination of Canadian and European bottled water with antimony from PET containers* (2006)
- 565 Clean by Design, *Fibre selection* (2012)
- 566 See <http://www.fibersource.com/fiber-products>
- 567 See https://www.econyl.com/assets/uploads/ECONYL_brochure_150318_EN.pdf
- 568 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.17
- 569 Ibid., p.17
- 570 See <http://www.fibersource.com/fiber-products>
- 571 See <http://fibersource.wpengine.com/fiber-products/acrylic-fiber>; <http://www.bbc.co.uk/schools/gcsebitesize/design/textiles/fibresrev4.shtml>
- 572 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), pp.17-18
- 573 See <http://fibersource.wpengine.com/fiber-products>
- 574 Singh, K., *Analysis of spandex/cotton elastomeric properties: Spinning and applications* (2012)
- 575 See <http://fibersource.wpengine.com/fiber-products/spandex-fiber>
- 576 Turley, D.B., et al., *The role and business case for existing and emerging fibres in sustainable clothing: Final report to the Department for Environment, Food and Rural Affairs (Defra)* (2010), p.115
- 577 Textile Exchange, *Preferred fiber market report* (2016), p.55
- 578 See <http://www.bbc.co.uk/schools/gcsebitesize/design/textiles/fibresrev2.shtml>
- 579 See <http://www.bbc.co.uk/schools/gcsebitesize/design/textiles/fibresrev4.shtml>
- 580 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.13
- 581 Clean by Design, *Fibre selection* (2012)
- 582 Turley, D.B., et al., *The role and business case for existing and emerging fibres in sustainable clothing: Final report to the Department for Environment, Food and Rural Affairs (Defra)* (2010), p.107
- 583 Clean by Design, *Fibre selection* (2012)
- 584 Fashion+, *Textile opportunities for Cradle to Cradle Certified™ Products Program* (2014), p.23
- 585 See <http://www.fibersource.com/fiber-products/>
- 586 See <http://www.fibre2fashion.com/industry-article/1970/properties-of-bamboo-fibre>; <https://www.eileenfisher.com/sustainable-fibers/choosing-tencel-over-viscose>
- 587 See https://www.patagonia.com/on/demandware.static/Sites-patagonia-us-Site/Library-Sites-PatagoniaShared/en_US/PDF-US/bamboo_rayon.pdf
- 588 Changing Markets Foundation, *Dirty fashion* (2017)
- 589 See <http://www.lenzing.com/en/responsibility/ecological-responsibility/eco-labelsawards.html>
- 590 Clean by Design, *Fibre selection* (2012)
- 591 See <http://canopyplanet.org>
- 592 See <http://www.fibersource.com/fiber-products>
- 593 Ibid.
- 594 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.16
- 595 See <http://www.lenzing-fibers.com/en/tencel>
- 596 See <http://www.fibersource.com/fiber-products>
- 597 See <http://www.bbc.co.uk/schools/gcsebitesize/design/textiles/fibresrev2.shtml>
- 598 See <http://www.bbc.co.uk/schools/gcsebitesize/design/textiles/fibresrev4.shtml>
- 599 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.16
- 600 Turley, D.B., et al., *The role and business case for existing and emerging fibres in sustainable clothing: Final report to the Department for Environment, Food and Rural Affairs (Defra)* (2010), pp.13, 108
- 601 Congressional Research Service, *Hemp as an agricultural commodity* (2017), p.7
- 602 Textile Exchange, *Preferred fiber market report* (2016), p.55
- 603 See <http://www.bbc.co.uk/schools/gcsebitesize/design/textiles/fibresrev2.shtml>
- 604 Business for Social Responsibility, *Apparel industry life cycle carbon mapping* (2009), p.8; Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.14
- 605 See <http://www.patagonia.com/recycled-wool.html>
- 606 See <http://sff.arts.ac.uk/Fibre%20Processing/woolprocessing.html>
- 607 University of Oxford: Environmental Change Institute, *Annual review* (2006); Worrall, S., *Land of the living wind* (2004); Oecotextiles, *Wool* (9 June 2010)
- 608 See <https://www.eileenfisher.com/sustainable-fibers/were-working-on-it-chlorine-free-wool>



609 See <http://www.bbc.co.uk/schools/gcsebitesize/design/textiles/fibresrev2.shtml>

610 See <http://www.fibre2fashion.com/industry-article/1710/properties-and-characteristics-of-silk>

611 Ibid.

612 Fletcher, K., *Sustainable fashion and textiles: Design journeys* (2014), p.15

613 Ibid., p.15



ABOUT THE ELLEN MACARTHUR FOUNDATION

The Ellen MacArthur Foundation was established in 2010 with the aim of accelerating the transition to a circular economy. Since its creation the charity has emerged as a global thought leader, establishing circular economy on the agenda of decision makers across business, government, and academia. With the support of its Core Philanthropic Partners, MAVA and SUN, and Knowledge Partners (Arup, IDEO, McKinsey & Company, and SYSTEMIQ), the Foundation's work focuses on five interlinking areas:

EDUCATION

Inspiring learners to rethink the future through the circular economy framework

The Foundation has created global teaching, learning, and training platforms built around the circular economy framework, encompassing both formal and informal education. With an emphasis on online learning, the Foundation provides cutting edge insights and content to support circular economy education, and the systems thinking required to accelerate a transition.

The Foundation's formal education work includes Higher Education programmes with partners in Europe, the US, India, China, and South America, international curriculum development with schools and colleges, and corporate capacity building. The informal education work includes the global, online Disruptive Innovation Festival.

BUSINESS AND GOVERNMENT

Catalysing circular innovation and creating the conditions for it to reach scale

Since its launch, the Foundation has emphasised the real-world relevance of the circular economy framework, recognising that business innovation sits at the heart of economic transitions. The Foundation works with its Global Partners

(Danone, Google, H&M, Intesa Sanpaolo, NIKE Inc., Philips, Renault, and Unilever) to develop scalable circular business initiatives and to address challenges to implementing them.

The Circular Economy 100 programme brings together industry leading corporations, emerging innovators, affiliate networks, government authorities, regions, and cities, to build circular capacity, address common barriers to progress, understand the necessary enabling conditions, and pilot circular practices, in a collaborative, pre-competitive environment.

INSIGHT AND ANALYSIS

Providing robust evidence about the benefits and implications of the transition

The Foundation works to quantify the economic potential of the circular economy model and develop approaches for capturing this value. These insight and analysis feeds into a growing body of economic reports highlighting the rationale for an accelerated transition towards a circular economy, and exploring the potential benefits across stakeholders and sectors.

The circular economy framework is evolving, and the Foundation continues to widen its understanding by working with international experts, key thinkers, and leading academics.



SYSTEMIC INITIATIVES

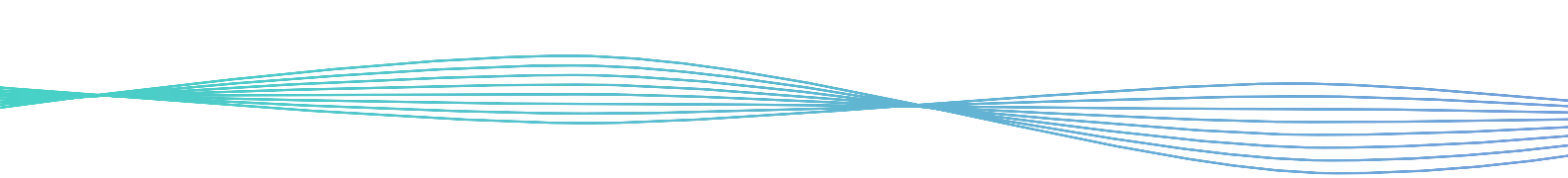
Transforming key material flows to scale the circular economy globally

Taking a global, cross-sectoral approach to material flows, the Foundation is bringing together organisations from across value chains to tackle systemic stalemates that organisations cannot overcome in isolation. Plastics was identified through initial work by the Foundation with the World Economic Forum and McKinsey & Company as one of the value chains most representative of the current linear model, and is the focus of the Foundation's first Systemic Initiative. Applying the principles of the circular economy, the New Plastics Economy initiative, launched in May 2016, brings together key stakeholders to rethink and redesign the future of plastics, starting with packaging. Building on the success of this first Systemic Initiative, textile fibres became the Foundation's second material stream focus, with the launch in May 2017 of the Circular Fibres Initiative.

COMMUNICATIONS

Engaging a global audience around the circular economy

The Foundation communicates cutting edge ideas and insight through its circular economy research reports, case studies, articles and books. It uses relevant digital media to reach audiences who can accelerate the transition, globally. The Foundation aggregates, curates, and makes knowledge accessible through Circulate, an online information source dedicated to providing unique insight on circular economy and related subjects.



© Copyright 2017 Ellen MacArthur Foundation

www.ellenmacarthurfoundation.org

Charity Registration No.: 1130306

OSCR Registration No.: SC043120

Company No.: 6897785