

Chapter 17

Clothing 2050: garment scenarios to drive circular material systems

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1 Introduction

“Living and designing in uncertain times requires us to work with resistance to existing structures and offer hope by proposing new ones.” (Dolejšová et al 2021)

This chapter looks ahead - using a framework of circular materials - through the eyes of consumers, at a range of garments and how they might be created, purchased, used, recirculated, recreated and regenerated. Designers working with creative futures thinking can contribute to ideas that lead to scalable ventures if their thinking is underpinned by systemic material knowledge and they make decisions in collaboration with users and other experts.

This chapter offers visions – ‘garment scenarios’ - for clothing that could be circular, lower in impact and ethically produced whilst meeting everyday needs of different, imagined households. These visions show how circular fashion textiles innovations can enable new ways to enjoy clothing. These may flow within material systems and be supplied via new business

models. Recycled polyester, regenerated cellulose and compostable non-wovens are the materials systems used in the scenarios.

In Part 2 of the chapter, the context of the climate emergency, environmental and socio-economic concerns are highlighted, along with the material groups used for the scenarios, which challenge our understanding of current biological and technical cycles. In Part 3, the range of design research and practice methods used for prototyping with these materials is presented; specific materials and prototypes resulted from three large international consortia projects are discussed. Part 4 presents the scenarios for three different households, demonstrating how framing user needs with circular material systems can provide inspiration for new design challenges.

2 Socio-economic circular materials for fashion

Whilst much more is now known about the environmental and social pros and cons for all kinds of materials (Roos, S., Okcabol, S., Rex, D. 2019; Textile Exchange 2020; WRAP 2021), better understanding and use of emerging circular (recyclable) options, each with environmental and socio-economic impacts, remains under-developed. The UN's Sustainable Development Goalsⁱ provide a set of targets both material and clothing stakeholders can aim for. It is, however, necessary to prioritise investment in materials and clothing that can build new industry infrastructures and innovation approaches, whilst contributing throughout the supply chain to the wellbeing of people, animals, planet, climate and culture. In a circular economy, materials and products are “designed in such a way that they can be reused, remanufactured, recycled or recovered and thus maintained in the economy for as long as possible”. (UNEP 2019)

Whilst biological and technical material cycles thinking gave designers more clarity around the natural and synthetic monomaterial options available to them, the fashion/textile field continues to make ‘monstrous hybrids’ (blends, e.g., cotton mixed with polyester). There are also materials that cross between the biological and technical cycles through processing; for example, milk can become acrylic fibreⁱⁱ and natural resources such as food waste can be synthesised into fibre. These need to be treated as technical materials rather than biological ones: what starts as natural can become synthetic. Some naturals may be able to compost safely – but are the nutrients reclaimed of value? After virgin materials have been processed their value may well lie in their ability to be cyclically regenerated time and time again (Goldsworthy 2021).

It is also paramount to think carefully about future feedstocks to ensure fibres such as cotton grown on land contributes towards regenerative agriculture and does not take away from future food production capacity. As fossil fuels for transportation and energy use get phased-out, reuse of existing polyester and use of bio-based polyester will become necessary. In a recent report by Biofabricate and Fashion for Good (2020) bio cellulose and bio polyesters – whilst coming from natural resources – are shown as new sub-categories within the man-made materials sphere. Mapping and classifying emerging materials enables the understanding of how they might be best used. This information and transparency is important as confusion and greenwashing persists, often generated by marketing departments of brands/retailers who seek to sell manmade materials as ‘naturals’ to consumers, by and large ill-equipped with the necessary knowledge to decipher and identify differences in fibres, materials and sources.

3 Research Projects and Prototypes

3.1 *Approach*

Emergent material systems cannot be created by any single stakeholder and require exploration through ambitious partnerships. The projects and prototypes in this chapter have used a range of methods, which all centre on collaborative practice-research approaches, including Design-Driven Material Innovationⁱⁱⁱ (DDMI) (Turbito *et al* 2018). Novel materials, exhibition and production prototypes represent the key outcomes from these efforts, which are derived from workshop models, design tools and reports.

The TEN^{iv} – a set of design strategies developed in the Textiles Environment Design group (a forerunner of CCD) in 2010 – were evolved in 2020 into a new framework for training designers in circular design. This approach maintains the range of values established in sustainable design but guides stakeholders towards how to build materials and products into future circular flows, allowing not just product longevity, but for a multitude of ‘circular speeds’, in recognition of the wide-ranging patterns and habits of clothing use that different people have (Earley 2017; Goldsworthy & Politowicz, 2019).

Whilst both sustainable design and circular design approaches require collaborative efforts around lifecycle frameworks to enable diverse stakeholder engagement, they differ because circular design demands that the material be regenerated into new resources. (In other words, a product can be sustainable, with careful consideration given to all its lifecycle stages, but may not necessarily be able to be circular as well.) Workshops and discussions with users, producers, policy makers, designers, engineers and others generated holistic insights for future design briefs. All participants were physically placed around a lifecycle worksheet. Participation in science and industry panels and discussions helped to build a broader knowledge around new material fields and future user behaviour, which could be modelled into future design and engineering propositions (Earley 2020).

The fictional users in the scenarios have been created by projecting forward 30 years by reading forecasts about 2050 and aligning the demographic to Generations X and Z^v and Generation Alpha (McCrindle 2018). This was achieved by a combination of reflecting on primary research from the three projects described in the next section of this chapter and being informed by the future-focused writings of Jonathan Porritt (2013); and Figueres and Rivett-Carnac (2021).

3.2 Design strategy and lifecycle speeds in the Mistra Future Fashion Programme

The Mistra Future Fashion^{vi} Programme began in 2011 and was co-ordinated by Research Institutes of Sweden. In the first phase a training programme using The TEN was created for designers at H&M's Head office in Stockholm. The process led the New Development team through product redesign tasks, taking best-selling products and finding ways those products could be improved, scoring them before and after using the Higg Index^{vii} (Earley *et al* 2016). In 2014, back in London, materials and prototypes were made by the CCD researchers in order to understand more about some of the ideas around product lifecycles conceived during the training^{viii}. How materials and fashion products of different life spans could be designed to move at different speeds were explored. In the second phase of the research (2015 – 2019)^{ix}, material scientists were paired with lifecycle assessment experts and design researchers in order to produce and evaluate circular fashion prototypes that were both ultrafast (Paper Leather Jacket, Figure 17.3, right) and super-slow (Service Shirt, figure 17.1, left). Through a residency with Filippa K, a luxury fashion label, a recyclable rPET raincoat (Eternal trench, figure 17.3, left) and a disposable (domestically compostable) 'paper' dress was made by the designers at the brand (Throwaway Dress, figure 17.1, right).

3.3 Prototyping with waste cotton and polyester in the Trash-2-Cash Project

The aim of the Trash-2-Cash project^x was to develop a design-driven material innovation methodology (DDMI) within the context of circular textiles (Tubito *et al* 2018). Working with 17 partners across 10 countries, the partners took waste textiles (hospital bed sheets, other service industry products and polyester clothing) at the end of their useful lives and made new materials with added functionality. The final six prototypes highlighted the opportunities of using chemical regeneration processes to create waterproofing, wicking (ReAct Mid-layer, figure 17.3, middle) and alternatives to polyester fleece for kidswear (ReBorn ReWorn, figure 17.2, middle). In one of the prototypes, blue cotton bedding from hospitals was used to make a pale blue shirt in lyocell^{xi}, designed with a zero-waste pattern and a business model that included an overprinting service, where dyestuff would be printed on top of used products (Zero° Shirt, figure 17.1, middle).

3.4 Developing scenario concepts for biobased materials in the Herewear Project

The Herewear Project^{xii} started in 2020 and uses agricultural waste (seaweed, manure, straw) to make new biomaterials for localised, extended-life circular clothing contexts. The research facilitated the understanding of how new bio-based garments can be produced in micro-factories to work in use loops via service models: rented, shared, swapped, repaired, re-used, re-purposed, upcycled and recycled. Material Portraits^{xiii} were created by mapping bio-based materials, tracing their routes through harvesting, to processing, to use applications, and to end-of-life options^{xiv}. This last aspect of the project has informed the garment scenarios below.

4 Garment Scenarios

The projects above have all contributed to an understanding around sustainable and circular design approaches, new materials and flows, low-impact production and finishing for textiles, the design, cut and construction of clothing, and the potential for new business models.

Table 17.1: Generational profiles, regenerative material systems and garment scenarios

Generational Profiles / Regenerative Material System	Recycled Polyester	Regenerated Cellulose	Tencel & PLA / Non-Woven
GENERATION Alpha: Entrepreneurs & Professionals			
<i>Early 2010s to late 2020s.</i> <i>In 2050 they will be 21-39 years of age.</i>	SERVICE SHIRT - Made from rPET - Extended by overprinting and remanufacture - Recycled into interiors	ZERO° SHIRT - Lyocell shirt made from blue cotton waste - Extended by overprinting - Recycled into viscose process	THROWAWAY DRESS - Made from Tencel and dyed with waste vegetables from restaurants - Recycled into domestic compost
GENERATION Z: Future Family			
<i>Born 1997 – 2012.</i> <i>In 2050 they will be 38-53 years of age.</i>	SPORTS COAT - Made from rPET - Extended by repair, reuse, customisation - Recycled into public transport interiors	BABY JACKET - Made from red cotton waste - Extended by repair and reuse - Recycled into viscose process	KIDS COSTUME - Made from PLA & decorated with compost safe marker pens - Recycled into domestic compost
GENERATION X: Retired Roamers			
<i>Born early 1965 to late 1980.</i> <i>In 2050 they will be 70-85 years of age.</i>	ETERNAL TRENCH - Made from rPET - Extended by repair and reuse - Recycled into material for brand's supply chain	REACT MIDLAYER - Made from cotton waste - Extended by repair - Recycled into viscose process	PAPER LEATHER JACKET - Made from paper and PLA, and dyed with walnut - Extended by repair - Recycled into industrial compost

The garment scenarios below were created align to three different household types. A summary of the key attributes of each garment scenario is presented in Table 17.1, framed by the material systems. Each garment scenario has been developed by thinking about how the garments were:

- Created – what are the clothes made from? How were they made?
- Purchased – how were the clothes acquired?
- Used – how are the clothes worn, used, cared for and stored?
- Recirculated – how are the clothes reused?
- Recreated – how are the clothes made into new products?
- Regenerated - how are the materials in the clothes made into new materials?

4.1 *Generation A: Young Entrepreneurs & Professionals*



Figure 17.1: Left, *Service Shirt* (Earley 2018); middle, *Zero° Shirt* (Trash-2-Cash project 2018); right, *Throwaway Dress* (Filippa K 2018).

In this house two couples split the rent and have developed multiple ways to share resources and keep their environmental impacts as low as possible. Co-habitation has become a desirable way to live after the 2020 pandemic; places where small communities could rely on each other within larger frameworks.

The Service Shirt (figure 17.1, left) is made from rPET, and is designed to be over-printed by a small brand in the town. Two people in the house share the shirt and enjoy being able to plan its next look. Through the prints they choose, they can make it more formal, or more casual,

depending on their needs. They know it will ultimately end up being remade into textile jewellery by local crafts people, long after its useful life. Eventually it will be regenerated into materials for train interiors. For them, it makes sense to reuse the immense amounts of polyester that earlier generations refined from fossil fuels.

One person in the house has a Zero° Shirt (figure 17.1, middle). It's their go-to garment for work. They like that it's been robustly made from waste cotton garments, and the soft lyocell makes it comfortable against the skin. They do repairs themselves, but if too busy, they use a local tailoring service. After the shirt finally becomes unwearable – stained, snagged, pilled – it goes to a local digital microfactory where it can be overprinted or recreated, and then recirculated in a number of ways. The owner has the shirt as part of a subscription service, so a fresh one is delivered as the old one is collected.

The fourth person in the house has a very active social life. They like to go out a lot, and they often like to experiment with their look. Rather than have a fixed set of clothes, this user owns fewer things, but also borrows, rents and swaps on a monthly basis. Occasionally, when they want to try a very new look out, they buy paper-like garments, like the Throwaway Dress (figure 17.1, right), which they can wear a few times and then bury in the garden. The act of exploring a new aspect of themselves, having new experiences, and then letting go is something they find beneficial to their sense of identity and mental health.

4.2 Generation Z: Future Family



Figure 17.2: Left, 'Sports Coat' (Parkour Parka by Earley 2019); middle, 'Baby Jacket' (ReBorn ReWorn Jacket from the Trash-2-Cash project 2018); right, 'Kids Costume' (Paper Tee by Kay Politowicz 2012).

Future families, like those today, have needs that change rapidly and tight financial budgets. They are interested in products and systems that give them variety; they understand and enjoy being part of a series of services and systems that ensure needs are catered to.

In 2050 recycled polyester is still in use – its lightweight yet durable properties mean that it stands the test of time in clothes that get used a lot. The Sports Coat (figure 17.2, left) is a unisex jacket that was used for sporting events in its first use phase. When dirty and stained, the jacket was overprinted at home by the kids, using an iron and a bespoke pattern. How the industry uses polyester really changed in the years leading up to 2050. After decades of being the cheapest fibre, taxation and regulations ensured that it became used for performance and high-end clothes. Low-cost polar fleece, common in kids clothing, was replaced by soft, brushed finish regenerated cellulosic materials.

The Baby Jacket (figure 17.2, middle) was made from used cotton from hotel and hospital bedding. Kids clothes are still swapped and exchanged; a host of new services are available to parents to get a return on purchased clothes or replacement pieces in bigger sizes and different colours.

As ever more diverse cultural moments are celebrated as part of daily life, the paper-like blank costume - Kids Costume (figure 17.2, right) - can be used, reused, adapted, drawn on and even taped up, to create hundreds of playful and celebratory looks to last a brief moment in a lifetime.

4.3 *Generation X: Retired Roamers*



Figure 17.3: Left, *Eternal Trench* (Filippa K 2018); middle, *ReAct Mid-layer* (from the *Trash-2-Cash* project 2018); right, *Paper Leather Jacket* (Kay Politowicz 2018).

In this house three people – the Retired Roamers - are co-habiting. In their mid- 70's these singletons have found new ways to grow old together. They are fashion philanthropists and travellers – picking up rental clothes from train station boutiques and booking Airbnb apartments complete with wardrobes made available to them. They are interested in spending their time and money well and looking after themselves, and each other.

The *Eternal Trench* (figure 17.3, left) is made from vat dyed rPET pellets. One of the Roamers invested in this classic piece 30 years ago. Over time it has been repaired by the brand, and re-waterproofed by the owner at home, using an organic spray. It is now ready for recycling – the resulting pellets will be used to make high-end wallcoverings. The owner will trade the coat in for points, which they can use for international train travel.

Another Roamer is still very fit, and spends hours cycling. The Peloton creates domestic energy and cycling outside is easy and safe because of the widescale investment in cycleways that transformed cities 20 years ago. The ReAct Mid-layer (figure 17.3, middle) is made from regenerated cellulose – in this case using local agricultural waste (straw) – which has been used to create fibres that have natural sweat-wicking properties physically engineered-in at the extrusion stage. Thousands of small brands across Europe make such clothing using a network of digital micro factories; local waste is used to make local fibres and clothing, using local businesses – made economically efficient by software that links all the stakeholders across the circular supply chain.

The Paper Leather Jacket (figure 17.3, right) is a purchase from a company that uses paper and textile waste to make lightweight but strong non-woven materials for short life fashion. These garments are sold across European cities in vending machines; these garments replaced much of the impulse buying that was so common with fast fashion in the first part of the 21st century. These garments can be worn several times, never washed, and then composted at home or in designated places in public parks.

5 Conclusion

Making low-impact long-life circular clothes that don't get worn because they are unattractive, undesirable or impractical is a waste of an immense level of resources. It is vital that we design for future needs, anticipating ways to offer clothing that enables and supports a diversity of lifestyles.

The key takeaways for the stakeholders involved in the ideas presented through the garment scenarios in this chapter are:

- Offering clothing with different lifecycle speeds can enable us to reduce the impact from waste, overproduction and overconsumption, by creating garments that better suit user needs and diverse, ever-changing lifestyles.
- Existing polyester can be recycled into products that don't need to be put in a washing machine (and add to microfibre fibrillation impacts), interior products and hard surfaces for public transport, for example.
- Regenerated cellulose processes can provide an opportunity to use end-of-life cotton, pre-industrial waste and agricultural waste for engineered fibres.
- Composable non-wovens may provide solutions for short-life clothing that are currently overlooked in the industry.
- New business models can support the sharing economy for clothing, offering mending and alterations, making, swapping, renting and subscriptions, etc., in physical and digital formats.

This chapter brings together the work of many researchers, in order to propose, through creating scenarios, how circular fashion textile systems can work together or in parallel, offering future users a variety of clothing options. It draws together different user needs, materials, technologies and economic contexts, exemplifying that circular design is deeply collaborative; it is about connecting up activities so that circles and loops are able to scale-up more easily. As we seek to change current extractive and exploitative industry practices, design researchers can bring diverse stakeholders together to explore new ideas in order to create proposals for imagined futures. These can serve as inspiration and as proposals for further inter- and trans-disciplinary exploration.

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ⁱ <https://sdgs.un.org/goals>

ⁱⁱ Casein / Milk fibre, <https://ecoworldonline.com/what-is-milk-fiber-yarn/>

ⁱⁱⁱ The DDMI methodology won an EU Innovation Radar award in 2019.

^{iv} The TEN, <https://www.circulardesign.org.uk/research/ten/>

^v Categories for generations, <https://www.beresfordresearch.com/age-range-by-generation/>

^{vi} Mistra Future Fashion Programme website, <http://mistrafuturefashion.com/>

^{vii} Higg Index, <https://apparelcoalition.org/the-higg-index/>

^{viii} Textile Toolbox, <http://www.textiletoolbox.com/>

^{ix} Project report, <http://mistrafuturefashion.com/wp-content/uploads/2019/10/K.-Goldsworthy-Circular-Design-Speeds-project.-mistra-future-fashion.pdf>

^x Trash-2-Cash project, <https://www.trash2cashproject.eu/>.

^{xi} Lyocell is a semi-synthetic fabric; a processed cellulosic fibre often made from wood pulp.

^{xii} Herewear project, <https://herewear.eu/>.

^{xiii} Material Portraits, <https://herewear.eu/category/material-portrait/>

^{xiv} For details of what end of life material processes are currently available, see <https://creacycle.de/en/the-process.html>