FASHION FOR GOOD

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COMING FULL CIRCLE: INNOVATING TOWARDS SUSTAINABLE MAN-MADE CELLULOSIC FIBRES

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1 Executive Summary

INTRODUCTION

Man-Made Cellulosic Fibres (MMCF), which are most commonly derived from wood, have the third largest share in global fibre production after polyester and cotton. They are a set of fibres with increasing importance – MMCF production has doubled in the last 30 years and is forecast for continued growth over the coming years. MMCF production has great potential from a sustainability perspective; moving production away from oil-derived synthetic fibres and reducing the depletion of freshwater through reduced cotton cultivation.

KEY ISSUES

Central to the sustainability credentials of MMCF are responsible sourcing practices and production processes; ensuring that harvesting of trees is done at a replenishable rate and closed-loop processes are used. Despite improvements, environmental organisation Canopy estimates that approximately one third of MMCF is procured from ancient and endangered forests – posing a grave threat to the environment and our ecosystems. Moreover, on the demand side, the fashion system that MMCF enters into is predicated upon a linear system; extracting virgin resources for production and disposing of textiles after a short amount of use – generating huge amounts of waste.

THE FUTURE MMCF SYSTEM

Strides have been made in laying out a future system – one that is regenerative and replaces the use of virgin wood coming from ancient & endangered forests with responsible forestry and alternative fibre sources – namely waste cotton textiles and other agricultural residue. Cotton textiles provide a fantastic source of cellulose to be regenerated into new MMCF fibres – requiring only 1 tonne of cotton waste input to produce 1 tonne of MMCF output, compared with 2.5 – 3 tonnes of conventional wood input.

This opportunity is unique and cannot be understated; if just 25% of the cotton and rayon textile waste was converted into regenerated MMCF, the need for virgin wood fibre in viscose production would be eradicated.

BARRIERS TO CLOSING THE LOOP

Textile recycling technologies provide an encouraging solution to close the loop on MMCF production, alleviating the burden on virgin resources and reducing textile waste. Two key forms of textile recycling exist; mechanical and chemical. The former is a more established industry, however, drawbacks including the requirement for high-purity feedstock and the shortening of fibres during recycling can reduce the performance at yarn and fibre stage and thus not provide a truly circular solution.

Chemical recycling technologies are best poised to tackle the bulk of textile waste, producing fibres of identical (or in some instances superior) quality. That said, key barriers still exist to scaling this technology – best summarised through the chicken and egg analogy: brands will not formally commit to offtake until it is cost competitive with virgin fibre; however, investors will not finance the innovation to commercialisation without the lack of demand signalled from the brands – leaving innovators in a difficult position.

Executive Summary

DISRUPTIVE INNOVATION HELPING TO CLOSE THE LOOP

A myriad of innovative solutions are being developed by established players and start-ups alike: some developing chemical recycling technologies that recycle cotton from pure cotton waste garments, others extracting the cotton from garments with blended fibres and finally those that target agricultural waste in the production of regenerated MMCF.

These innovations are nudging the needle; however, more must be done to move from siloed success stories to systemic change.

CONSORTIUM PROJECTS ENABLE INNOVATION TO SCALE

Consortium projects with multiple innovators can help to overcome the aforementioned barriers – providing innovators with industry expertise and support, helping brands harness the full capability of several innovations simultaneously, and finally, providing supply chain partners with access to potential scalable long-term implementation partners.

The Full Circle Textiles Project (FCTP), orchestrated by Fashion for Good, brings together the relevant stakeholders across the spectrum of chemical recycling of cellulosics, to bring structure to the innovation process, test their output with industry experts, and best enable the scaling of the technology.

The key FCTP stakeholders are: Fashion for Good, Laudes Foundation, Birla Cellulose, Evrnu, Infinited Fiber Company, Kering, Phoenxt, PVH Corp., Renewcell, Target and Tyton BioSciences.

WIDER INDUSTRY ACTION IS NEEDED

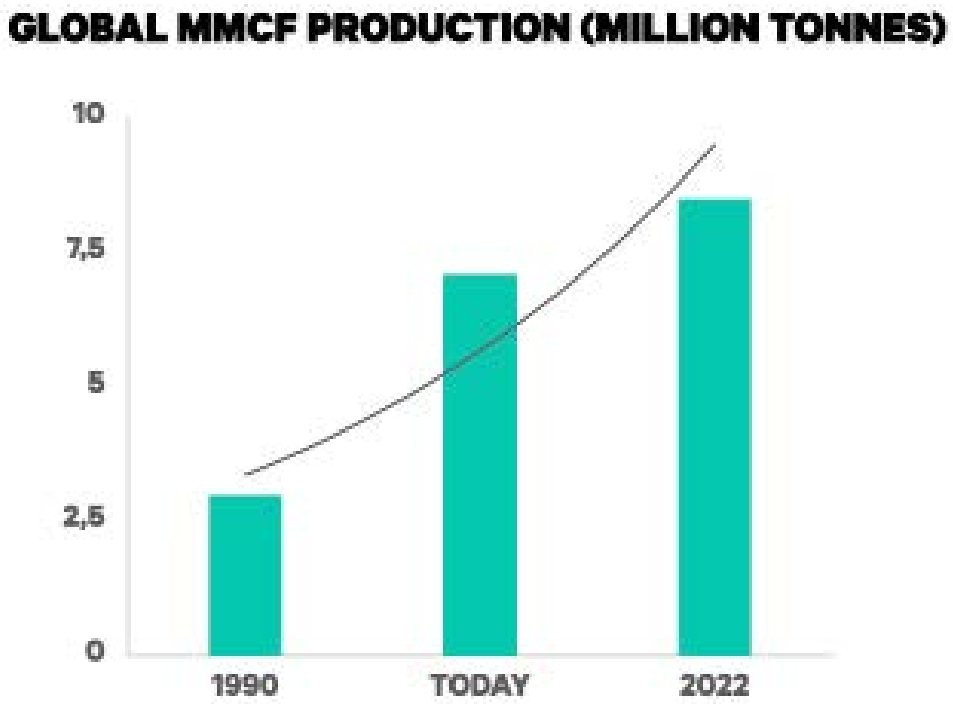
Scaling chemical recycling of cellulosic fibres cannot be achieved by one consortium project alone. A concerted, industry-wide effort is required to provide the incentive and financial means needed to accelerate the transformation to sustainable and closed-loop processes. Fashion for Good, through the FCTP, hopes to inspire other stakeholders to pilot, invest and ultimately secure offtake with chemical recycling innovators, catalysing the transformation to a more circular fashion system.

> **“A bold approach is needed to identify and scale innovations that drive sustainable change in the fashion industry. This multi-stakeholder consortium, a first-of-its-kind, addresses the most important barriers to scaling innovation, setting the precedent for all industry players with ambitions for disruptive innovation to follow.”**
>
> Katrin Ley, Managing Director, Fashion for Good

2 Introduction
The importance of man-made cellulosic fibres

Man-made cellulosic fibre (MMCF) are a group of fibres that are conventionally derived primarily from wood, and in some cases other sources of cellulose, such as bamboo or other plant matter. Cellulose is found in the walls of plant cells, helping plants and trees to stay upright. It is also a key component of cotton fibres, in which it is found in extremely pure form. Cotton is an example of a 'natural' cellulose fibre and is processed differently from MMCF – with the latter following a dissolution and extrusion process, thus being referred to as 'man-made'. In the majority of MMCF production, wood is mechanically shredded and then processed multiple times into sheets of cellulosic 'pulp'. These sheets are then dissolved to form a viscose solution, which is extruded through spinnerets in a wet spinning process into fibre.

Man-Made Cellulosic Fibres (MMCF) are the third most commonly used fibre in the world, behind polyester and cotton. With an annual production volume of approximately 7.1 million tonnes, MMCFs constitute around 6.4% of the total fibre production volume[1]. Perhaps more telling of MMCF's significance in the global fibre market are their rate of growth – the production volume has more than doubled from just over 3 million tonnes since 1990[2]. This rate of growth is not expected to subside, with Textile Exchange forecasting a Compound Annual Growth Rate (CAGR) of over 6% in MMCF production between 2019 & 2022[3]. In comparison, it is forecasted that cotton fibre will grow at a CAGR of approximately 3% between the period of 2019 to 2024 – further demonstrating MMCF's increasing significance[4].



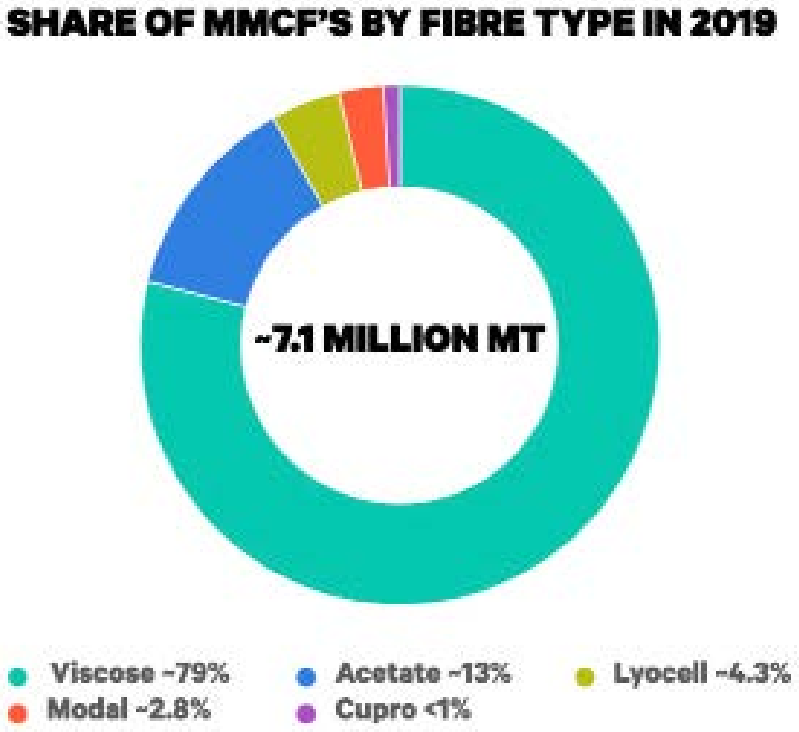
Source: Textile Exchange, 2020. Market Report 2020. Preferred Fiber & Materials. [online] Available at: https://textileexchange.org/wp-content/uploads/2020/06/Textile-Exchange_Preferred-Fiber-Material-Market-Report_2020.pdf

Introduction

MMCFs encapsulate a range of different fibres – all possessing different performance characteristics and different environmental impacts. Viscose has 79% share of production volume, with acetate holding 13% (its primary application being non-textile).

Lyocell has a 4.3% market share; however it is estimated to grow at a CAGR of approximately 15% in the coming years, which is the fastest of any MMCF[5]. Lyocell's rapid forecasted growth can be put down to two main factors: first, the manufacturing process is less chemically intensive than viscose and does not use toxic compounds as reagents (e.g. carbon disulphide), leading to a 99.7% solvent recovery rate[6]. Second, as a fibre it has greater strength compared with viscose and cotton.

Modal and cupro make up the last two types of MMCFs, contributing a market share of 2.8% and less than 1% percent respectively.



Source: Textile Exchange, 2020. Market Report 2020. Preferred Fiber & Materials. [online] Available at: https://textileexchange.org/wp-content/uploads/2020/06/Textile-Exchange_Preferred-Fiber-Material-Market-Report_2020.pdf

A SHORT HISTORY OF LYOCELL

Lyocell was first commercially produced in the early 1990's by Courtaulds Fibres in the UK, marketing the lyocell fibres under the brand name 'Tencel'. The patented process was later acquired and further developed by Lenzing; however, since then other large MMCF producers have entered the space. Notably, in February 2019 Birla Cellulose commissioned a new plant that will double its lyocell capacity and Sateri announced a 20,000 tonne per annum capacity lyocell production plant in Shandong, China.

Introduction

According to Canopy, today there are 42 dissolving pulp mills providing across 17 countries, with more than half located between Brazil, Indonesia, China, USA, South Africa and Canada. In the fibre production stage, China dominated the MMCF production – manufacturing two thirds of all MMCFs, with USA, India, Austria and Indonesia all producing between 4% - 8% of man-made cellulosic fibres[7].

With regards to the organisations behind the market, the 2019 Canopy Hot Button Report revealed that the Chinese Sateri (part of Royal Golden Eagle Group) has the largest proportion of global production capacity, holding a market share of almost 16% in 2019. The globally operating Austrian headquartered Lenzing held the second largest market share of almost 15%, with Indian Aditya Birla Group's Birla Cellulose holding close to 13%. Finally, Tangshan Sanyou's production accounted for almost 12% of the viscose production – thus demonstrating that four organisations account for over 50% of the global total viscose production[8].

MMCF production has great potential from a sustainability perspective; moving production away from oil-derived synthetic fibres and reducing the depletion of freshwater through reduced cotton cultivation. Furthermore, MMCF commands considerably less land-usage than cotton, as well as no pesticides or insecticides. However, imperative to the sustainability credentials are responsible sourcing practices and production processes, such as replanting forests at a faster rate than harvesting, and recovering the chemicals used in production in a closed-loop manner.

Canopy estimated that approximately one third of MMCF still comes from ancient and endangered forests[9]. To put that into context, the viscose fibre produced in 2019 translates into the cutting of 150 million trees, meaning that roughly 50 million could have originated from ancient and endangered forests[10]. Moreover, complementary to more responsible sourcing is incremental improvement in production processes and alignment to industry standards, as well as disruptive innovation. Only then, with all elements working together, will we transition to a more sustainable and circular MMCF industry.

3 Key Issues
In man-made cellulosic fibre production

The current system of virgin MMCF production has issues that can be broadly categorised into three key areas:

1. When sustainable forestry practices are not followed, the extraction of raw material is contributing to the continued deforestation and logging of forests, particularly important are ancient and endangered forests, as well indigenous communities' traditional lands;
2. The continued production of garments containing virgin material is leading to a large amount of textile waste that is not recycled back into textile fibre, a significant portion of which is destined for landfill or incineration;
3. The manufacturing process of most MMCFs contains the use of hazardous chemicals, which if not managed correctly using the latest technologies, can harm workers and contaminate local ecosystems.

THE RELATIONSHIP BETWEEN MMCF PRODUCTION AND FORESTRY

It is well known that drastic action must be taken in order to meet the ambitious climate targets set in the Paris Agreement – that is to limit global temperature rise to well under 2 degrees above pre-industrial levels by 2030. After that point, it is said that the catastrophic impacts of climate change are irreversible[11].

Given the magnitude of the issue, a multi-faceted approach that influences both production and consumption habits must be pursued. As well as transitioning to a more decarbonised economy, recent studies from the UN have found that the maintenance and restoration of forests are equally as crucial in supporting the climate goals[12]. It is projected that nature-based solutions, of which restoration and management of forest is a central component, can provide a low cost solution to sequester significant amounts of the carbon needed through to 2030 to limit warming to less than 2 degrees[13].

Within the MMCF supply chain, there is particular importance on the preservation of ancient and endangered forests. These can be original forests that have never been industrially logged, rare forests that are not abundant on a global level, and/or forests that contain high concentrations of rare and endangered species[14]. From a carbon sequestration perspective, ancient and original forests hold disproportionately greater significance, storing 40x more carbon per hectare than industrial plantation forests[15].

Aside from the carbon sequestration effects, restoring and managing natural forests can help to protect communities downstream from flooding, as well as protecting biodiversity[16]. Forests are home to 80% of all land-based biodiversity, providing irreplaceable variety to our ecosystems helping to ensure its resilience and continued productivity[17].

Limpakuwus Pine Forest, Banyumas, Indonesia

Key Issues

The forestry practices followed by MMCF producers are pivotal in influencing the sustainability of industry. For example, progressive MMCF producers that follow sustainable forestry practices, such as replanting more trees than they are harvesting, can have a net positive environmental impact through increased carbon sequestration. However, irresponsible practices lead to deforestation and thus significant release of carbon dioxide, as previously mentioned. Canopy, through their CanopyStyle initiative, is making huge strides in working with pulp and viscose producers to ensure sustainable forestry practices – having engaged almost 85% of the entire global market of MMCF producers in the initiative. Presently, 42.5% of global market share of MMCF producers achieved a 'green shirt' in the 2019 Hot Button Ranking.

WHAT IS THE CANOPY HOT BUTTON RANKING?
The Hot Button Ranking reflects the growing commitment of the textile and fashion industry to look beyond simply mitigating risk. With the goals of making the viscose supply chain more sustainable, as well as institutionalising the long-term solutions required for a stable future for the world's ancient and endangered forests, the ranking focuses on:

- **Producers' level of risk of sourcing from ancient and endangered forests**
- **Producers' leadership on advocating for conservation legacies,**
- **Producers' work to advance the commercial-scale production of fibres using innovative and alternative feedstocks, such as leftover straw or post-consumer recycled clothing.**

The assessment analyses measurable actions by producers and the methodology is transparent and replicable.

The Fashion for Good FCTP will not directly address the problem area of sustainable forestry, but will instead look to reinforce and align with this progress whilst working to relieve pressure on forests through replacing fibre sources with circular alternatives.

THE RELATIONSHIP BETWEEN THE CURRENT FASHION SYSTEM AND WASTE GENERATION

The current system of producing, distributing and disposing of clothing occurs almost entirely in a linear 'take-make-dispose' model – that is, extracting virgin resources, using garments for a short period before disposing of them, whereby the materials are lost to landfill or incineration.

In many parts of the world, the infrastructure for collecting the disposed garments is improving, therefore increasing the amount of used garments being collected. For example, incoming EU legislation mandating the separation of textile waste from other waste streams by 2025 will only accelerate the amount of textiles being collected[18]. However, the fraction of these garments that can be resold domestically or exported to be resold is shrinking – which has traditionally been the financial driver for the textile sorting industry[19].

Key Issues

The proportion of reusable textiles is reducing because of three key reasons:

- There are more low quality, 'fast-fashion' items entering the textile waste stream that retain less value[20].
- The traditional export markets are becoming saturated with used garments – with some countries deciding to ban or place tariffs on the imports of used garments[21].
- Consumers and brands are taking greater ownership of the reuse market, meaning discarded garments are often those that are non-reusable.

This, coupled with the challenges with closing the loop through textile-to-textile recycling (as discussed below), has meant that over 70% of clothing discarded ends up in landfill or incineration, with less than 1% being incorporated in the production of new textiles[22]. To put that into perspective, the rate of disposal is equivalent to one garbage truck of textile waste being landfilled every second[23]. This problem is exacerbated given the fact that over half of the textiles produced today are from synthetic fibres, which are conventionally not biodegradable and have been found to shed microfibres into the surrounding environment.

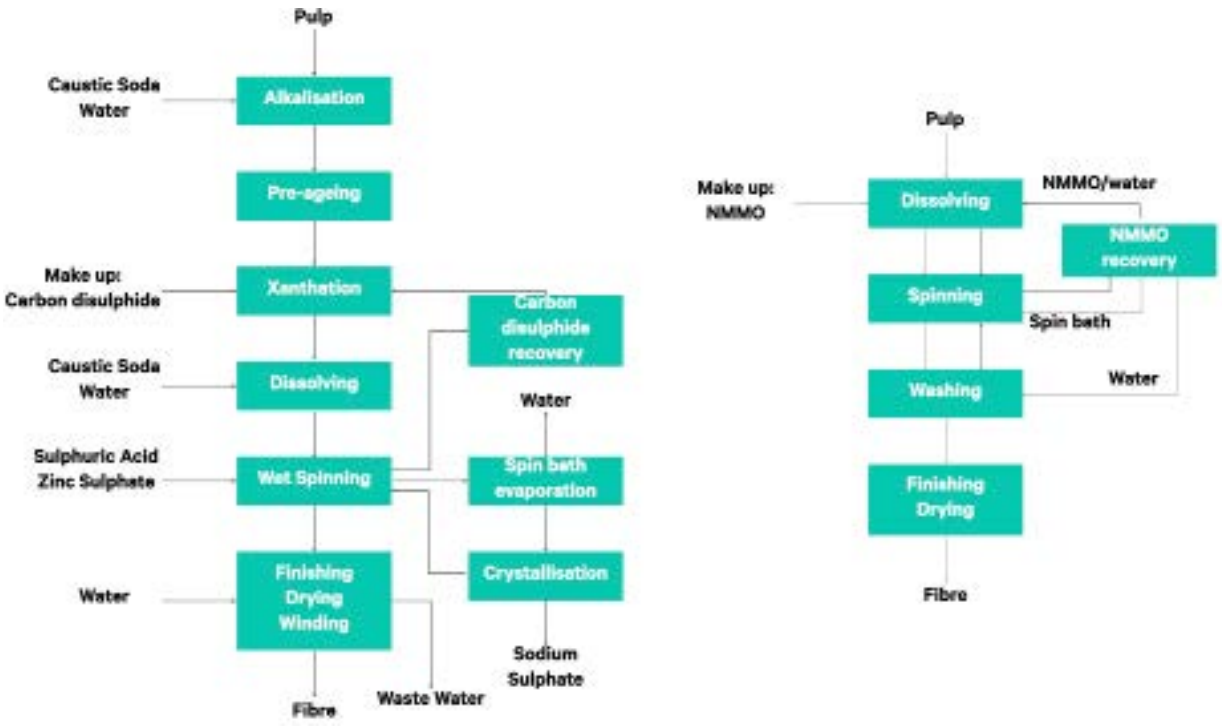
The recycling of textile waste that does occur consists of cascading the waste to other industries in the production of lower value applications – such as insulation, mattress stuffing and industrial wipes. The sheer quantity of textile waste being generated is further increasing given the underutilisation of clothing. For example, the emergence of fast fashion and falling costs has meant that clothing production has doubled from 2000 to 2014[24]. In today's trend-driven system, consumers keep clothing items about half as long as they did 15 years ago[25]. It has been estimated that over half of fast fashion items produced are disposed of within one year – leading to an extreme throwaway culture[26]. The consequence of all of the highlighted converging factors is a huge amount of non-reusable textile waste that is destined for landfill or incineration at large environmental cost.

As shown later in this report, innovation in textile-to-textile recycling holds significant force to accelerate the transition to a fashion industry that generates less waste, with more existing materials re-entering the system. Given this opportunity, the FCTP has been formulated to address this issue directly - transforming textile waste into new garments of indistinguishable quality.

Key Issues

THE RELATIONSHIP BETWEEN MMCF PRODUCTION AND HAZARDOUS CHEMICALS

The production of (most) MMCFs includes a number of highly corrosive and toxic chemicals. Whilst discharge and dangerous levels of exposure were more prevalent in the early years of MMCF manufacturing (1970's – 1980's), without adequate chemical management it still remains a threat today.



Source: Simplified from Shen, L., Worrell, E., & Patel, M. K. (2010). Environmental impact assessment of man-made cellulose fibres. Resources, Conservation and Recycling, 55(2), 260–274. doi:10.1016/j.resconrec.2010.10.001

Central to this is the release of carbon disulphide (CS_2), a hazardous chemical that is used as a solvent in the production of viscose and modal[27]. Exposure to CS_2 for prolonged periods can cause a wide range of illnesses - ranging from organ damage to endocrine disruption. Other hazardous chemicals used in the dissolving of pulp and spinning of MMCF include caustic soda (NaOH) and sulphuric acid (H_2SO_4) - both of which are commonplace in chemical industries; however do both pose a threat to human health if not appropriately managed[28]. Finally, it is crucial to note that the adverse effects of the aforementioned chemicals are not limited to the workers within the manufacturing sites; without adequate chemical management the surrounding areas can become affected by the discharge of chemicals – harming the health of local communities and surrounding ecosystems.

Key Issues

In the last two decades, there has been considerable development of technologies, referred to as the closed loop technologies or Best Available Technologies, that address the risks to safety, health and environment. These technologies allow the chemicals to be recovered and recycled back into the process. Progressive viscose producers now apply these control technologies, thereby keeping the work environment and ambient air conditions below the limits prescribed by World Health Organization (WHO) and Occupational Safety and Health Administration (OSHA).

The problem of hazardous chemical discharge is further being addressed through industry-led initiatives, for example the work of Zero Discharge of Hazardous Chemicals (ZDHC). In April 2020, the ZDHC Roadmap to Zero Programme, a collaboration of brands, supply chain players and manufacturers, released a set of guidelines for responsible production of MMCF – across wastewater management, sludge, air emissions and chemical recovery during the fibre production stage.

The aspiration is to create an aligned approach for manufacturing facilities across the world to generate cleaner outputs whilst encouraging more closed-loop processes. The guidance provides best practices of responsible manufacturing, including technologies and techniques to recover hazardous chemicals (e.g. carbon disulphide and sodium hydroxide) as well as prescribing percentage rates of chemical recovery for manufacturing facilities to be considered as 'foundational, progressive or aspirational[29]'. In doing so, ZDHC hopes to implement its roadmap with defined milestones for fibre manufacturing facilities to advance towards progressive and aspirational performance levels as presented in EU BREFS documents.

WHAT IS EU BREFS?
The EU Best Available Techniques References (BREFS) define the most advanced technologies that are available today to control and minimize the emissions to environment from the industrial processes and reduce the resource consumptions.

These documents also describe the associated emissions and consumption levels that can be achieved by applying the Best Available Technologies. The BREFS for the viscose staple fibre industry are available in document called "Best Available Technology for production of Polymers". It is considered to be the most comprehensive and ambitious standard addressing pollution to air and water as well as defining the consumption norms for the raw material in the viscose fibre manufacturing process.

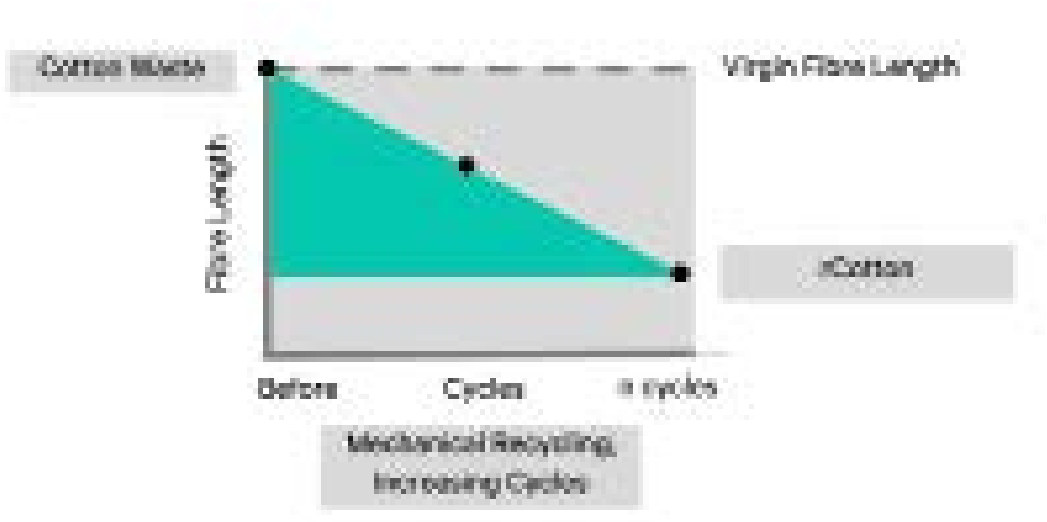
Whilst this is clearly an important issue for the industry to tackle, the aforementioned initiatives led by ZDHC and the European Commission are making fantastic steps in addressing them and so the Fashion for Good Full Circle Textiles Project will not be addressing this problem area directly.

4 Current Barriers

Why closing the loop in MMCF production remains a challenge

As introduced, the current fashion system is operating in a linear manner of extracting virgin resources and disposing of clothing once it has reached its perceived end-of-life, generating a huge amount of waste. Textile-to-textile recycling holds significant potential to close the loop in MMCF – alleviating the strain on virgin resources (problem 1) and reducing the amount of used textiles going to landfill / incineration (problem 2). Moreover, using cotton waste is more efficient than virgin wood from a yield perspective given the purity of cellulose in cotton. It only requires approximately 1 tonne of cotton waste to generate 1 tonne of cellulosic pulp, compared with 2.5 – 3 tonnes of wood required for the same 1 tonne output[30].

Closing the loop in MMCF through textile-to-textile recycling can be done in two main ways – mechanical and chemical recycling. Mechanical recycling is a more established industry, with roots in the 'downcycling' industry – that is, producing materials used in insulation, industrial clothes or other lower-value uses. Mechanical recycling of textiles into new textiles is commonly done on high purity, long staple fibres such as wool and cashmere. The mechanical recycling process involves breaking down garments by chopping them into shredded fragments, pulling apart the fibres and then disentangling and aligning them using a carding process[31]. Inherent to the mechanical recycling process is the shortening of the fibres, reducing their performance during the yarn and fabric production. This makes it challenging to achieve the desired versatility and quality of finished garments using mechanically recycled fibres. It can therefore be argued that mechanical recycling of cotton does not provide a 'truly circular' solution given the continued degradation of fibre lengths in each cycle[32]. To combat this, the recycled cotton fibres are often blended with virgin ones, improving the performance but worsening the environmental footprint of the final output.

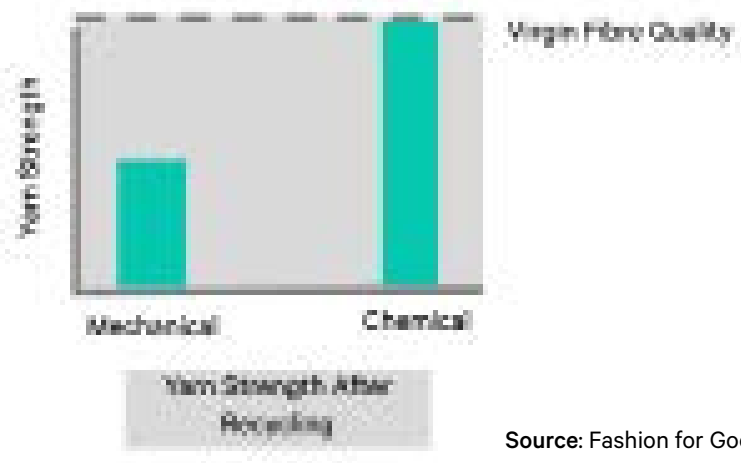


Source: Fashion for Good analysis

Current Barriers

Moreover, textile-to-textile mechanical recycling solutions require a high purity of feedstock. The low tolerance for contamination of other fibres is especially problematic given the high prevalence of blended fabrics entering the post-consumer waste stream – with research from the Netherlands estimating it to be around 40% of post-consumer textiles[33]. Finally, given mechanical recycling does not change the colour of the garments, they must be manually sorted into groups of colours, increasing labour costs to the process. Given all of the above, it could be said that textile-to-textile mechanical recycling has greater applicability to the post-industrial (rather than post-consumer) textile waste stream – whereby there is greater assurance of homogeneity of feedstock in terms of purity and colour.

On the other hand, chemical recycling of textile waste provides an encouraging alternative as it is able to overcome some of mechanical recycling's shortcomings. From a process perspective, chemical recycling breaks down the fibres into their chemical building blocks, then rebuilds them into new fibres of indistinguishable, or even superior quality[34]. Emerging chemical recycling technologies are also able to address blended-fibre garments. For example, polyester and cotton possess very different solubility characteristics, allowing for chemical recycling to separate and extract both fibres in a polycotton blend[35]. Specifically to cotton, which accounts for almost a quarter of the global fibre market, the process generally involves dissolving the cotton cellulose in a solvent and then wet spinning new fibres from the resulting pulp, in a similar way to the conventional viscose process and other man-made cellulosic fibres[36].



Source: Fashion for Good analysis

Whilst the technology holds great potential to close the loop on much of the textile waste, it still has a few crucial barriers to scale. First, aside from a few examples, investors have not demonstrated great appetite in the space, with the investments being perceived as too risky given the high capex costs and the long timeframe to commercialisation. Moreover, the perceived risk of the technology is compounded by the lack of formalised brand engagement with innovators – on the whole there seldom exists offtake agreements and other co-development contracts. Without the demand for the offtake signalled, it is challenging to attract financiers into the space.

Finally, given the lack of capital invested in the emerging industry, it has proven extremely challenging for innovators to reach cost-parity with the virgin alternative, whilst the output remains relatively small scale[37]. The relationship between the stakeholders can be characterised by the chicken and egg analogy - brands will not formally commit to offtake until it is cost competitive with virgin fibre; however, investors will not finance the innovation to commercialisation without the lack of demand signalled from the brands – leaving innovators in a difficult position.

5 A Vision For The Future

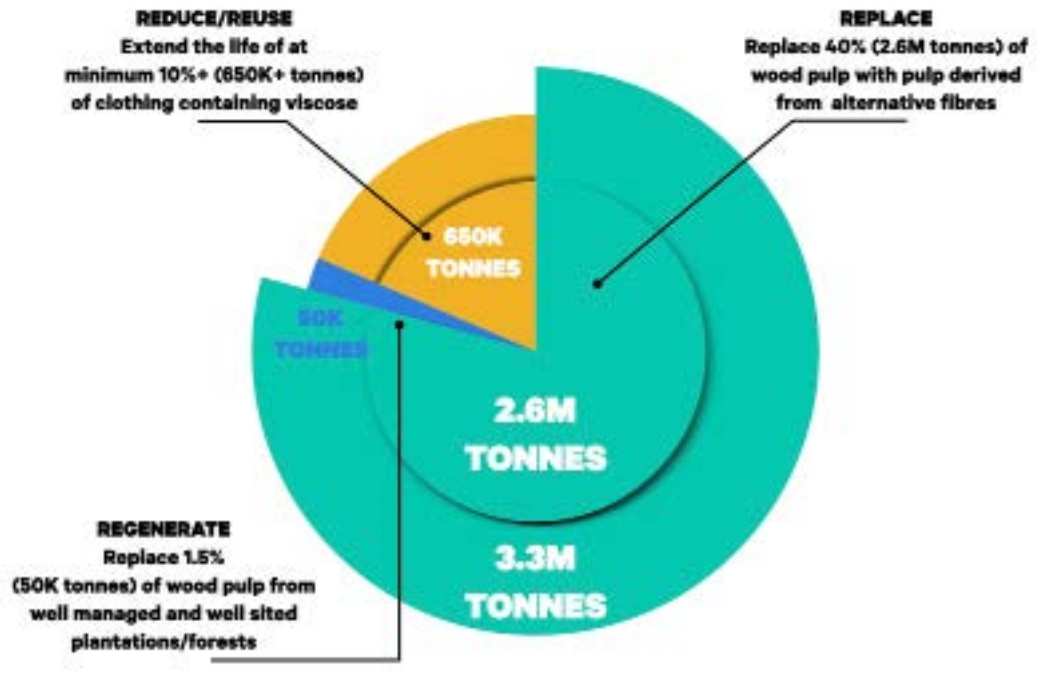
A vision for a more sustainable MMCF future system

Given the rising importance of MMCFs in the future fashion system, yet the persisting problems of virgin resource depletion and generation of textile waste, it is extremely important that the future value chain transitions to a more sustainable and circular one. There has recently been an emergence of initiatives that aim to address those problems and lay out a vision for a future system – notably Canopy's Next Generation Action Plan.

THE NEXT GENERATION ACTION PLAN

Canopy – the environmental organisation working to protect forests worldwide, conceived their Next Generation Action Plan to protect the 182 million tonnes of virgin wood fibre that are used for paper pulp annually, as well as the 3.3 million tonnes of wood that originate from ancient and endangered forests in the production of viscose pulp annually[38]. The Plan proposes the elimination of 70% of the pulp fibres coming from forests never-before logged and 30% of the pulp fibres from plantations that endanger rich carbon stores and terrestrial biodiversity.

Canopy's aim to displace ancient and endangered forest pulp from supply chains can be characterised by the 5R's: Reduce/Reuse, Recycle, Replace & Regenerate.



Source: https://canopyplanet.org/wp-content/uploads/2020/01/SURVIVAL-Next-Gen-Pathway.pdf – page 20

A Vision For The Future

REDUCE AND REUSE: Reduce consumption on the demand side of the supply chain through creative design and delivery systems and extend the lifespan of products such as shipping boxes and T-shirts.

RECYCLE: Increase the amount of recycled paper fibre in paper and packaging products.

REPLACE: Replace a significant amount of wood pulp with alternative fibre sources such as:

- Agricultural residues and fibre crops for paper;
- Waste cotton and rayon scraps and used garments for recycling into new viscose;
- Microbial cellulose fibre for viscose grown from food waste.

From the graph above, we see that the replace section is the most significant lever in transition to the Next Generation, whilst having large innovation potential, thus making it the subject of this report and associated Fashion for Good Full Circle Textiles Project.

REGENERATE: Plant new trees for wood pulp to fill the supply gap resulting from the restoration of priority forests that have already been degraded, or the re-siting of poorly sited plantations.

The Next Generation Action Plan proposed enables a radical reduction in the extraction of raw resources, optimises material efficiency, leads to better product reuse and shifts the use of conventional high-impact fibre sources to alternative, less damaging fibre sources (or better still, regenerative feedstocks) for manufacturing pulp for paper and viscose fabric goods.

The transformation of the global wood pulp supply chain proposed by Canopy requires significant investment, to the tune of $69 billion over a 10-year period[39]. However, given the uncertainty about future wood supply, diversifying the fibre basket for pulp is a salient business proposition as well as an imperative environmental strategy. Moreover, building and retrofitting mills can provide additional benefits such as economic development in rural regions and underemployed urban areas.

> **“Next generation solutions are the path to meeting the climate and biodiversity targets that scientists are calling for by 2030. We’ve seen promising momentum in recent years as we’ve worked with brands, producers and innovators to build strong market demand and Identified a great pipeline of game changing technologies. Now we need investment and broad industry adoption to make these Next Gen Solutions a commercially available reality.”**
>
> Nicole Rycroft Founder and Executive Director, Canopy

A Vision For The Future

Textile Exchange and Forum for the Future echo the ambitious action plan and progress to date of Canopy; proposing the vision of a MMCF production system that contributes to the strengthening of our social foundations and the regeneration of our ecological systems[40]. The interdependent and mutually reinforcing pillars of the 2030 MMCF system are as follows:

- **Regenerating ecosystems**: Restoring natural ecosystems, ensuring a carbon negative value chain and taking regenerative landscape approaches.
- **Producing with zero harm**: Managing chemicals and other inputs, zero emissions and closed-loop production systems.
- **Enabling circular systems**: Designing, incentivising and implementing circular value chains and zero waste.
- **Creating prosperity**: Distributing economic value equitably, applying living wage and equality, universal access to education and healthcare.
- **Upholding rights**: Community empowerment and related access rights, protecting the rights of individuals, indigenous people and other communities.

In order to achieve the vision outlined, there are ten key enablers highlighted; including collaboration across the value chain, accelerating innovation, sharing best practices and the introduction of novel forms and flows of financing.

Whilst the action plan proposed by Canopy and the vision from Textile Exchange and Forum for the Future are far-reaching and require a systemic shift in the MMCF value chain, there are a number of disruptive innovative solutions being pursued by established brands and start-ups alike, with support from the likes of Fashion for Good and Canopy. The ones highlighted in this report address the 'replace' bucket – that is, producing fibres through alternative feedstocks, in doing so also enabling a circular system through the use of otherwise 'waste' produce.

6 Closing The Loop

Disruptive innovation can help to close the loop

The examples of innovation below cover textile recycling technologies and the utilisation of agricultural waste feedstocks in the production of regenerated cellulosic pulp and/or fibre production.

RECYCLING

As explained in Chapter 4, textile-to-textile recycling provides huge opportunity to alleviate the burden on virgin resources, reduce the amount of textile waste generated, whilst also providing a more efficient process with a better input to output conversion ratio. This creates a fantastic opportunity to convert some of the 20 million tonnes of cotton fabric waste that are disposed annually into MMCFs[41]. A recent Canopy report forecasted that converting just 25% of the cotton and rayon textile waste into new dissolving pulp would completely eradicate the need for virgin wood fibre in the production of viscose. A myriad of technological innovations are emerging to convert cotton and other cellulosic garment waste into new regenerated cellulosic fibre, with both established players and disruptive start-ups addressing the opportunity:

ESTABLISHED PLAYERS

- Asahi Kasei, a Japanese chemical producer, introduced Bemberg – a GRS-certified regenerated cupro fibre made from 100% pre-consumer cotton linter with a production capacity of 17,000 tonnes annually[42]. The most common application for the fibre is in suit lining and lightweight sheer garments.

- In 2019, Birla Cellulose demonstrated their commitment to traceability, innovation and circularity through the introduction of the Liva Reviva line - a viscose fibre using 20% pre-consumer cotton fabric waste and 80% responsibly sourced wood pulp that can be traced from Tier 7 forest-level through their blockchain technology. Birla Cellulose developed the cotton recycling technology in-house and the fibre is certified by the Recycled Claim Standard[43]. Whilst launching this fibre on a commercial scale, Birla Cellulose are also developing products with recycled content of the fibre to 50% by the end of 2020. Birla Cellulose is also working on integrating post-consumer textile waste into their process and developing fibres based on alternative feedstocks[44].

Closing The Loop

- Lenzing, one of the largest viscose producers in the world, created Refibra – the first lyocell fibre made from recycled materials available on a commercial scale. When offered in 2017, it initially contained 20% pre-consumer cotton waste; however, that number has since increased to 30% in 2019 and now contains post-consumer waste too[45]. Lenzing's vision is to increase the recycled content to 50% by 2024, without compromising the quality of the fibres[46].

- Sateri, Shanghai headquartered fibre-producer part of the Royal Golden Eagle (RGE) Group, unveiled Finex – a next-generation MMCF made from post-consumer cotton textiles[47]. They collaborated with pulp producer Södra in the commercial production of recycled man-made cellulosic staple fibres, with recycled content below 5% currently[48]. It is Sateri's ambition to continue to innovate and collaborate with downstream players to increase the recycled content to 20%[49].

- Södra – the Swedish forest cooperative, announced its new dissolving pulp product named 'OnceMore®' in October 2019. The process is able to separate polycotton blends and extract the cellulosic fibres from the cotton stream. Södra currently only accept white polycotton (or pure cotton) fabrics, but are looking at a decolouring solution. The recycled content of the dissolving pulp began around 2-3% when launched; however, Södra are working to increase the recycled content to 20%, and eventually 50% by 2025 - with an aspirational output of 25,000 tonnes[51].

Image courtesy of Södra

- Tangshan Sanyou, which has over a 9% share of the viscose market, introduced a viscose staple fibre ReVisco in June 2019 – made from 50% post-consumer recycled content, with dissolving pulp supplied by Renewcell. This was successfully brought to market in April 2020, featuring in H&M's 'Conscious Exclusive' line[50].

INNOVATORS

The prominent innovators working in the regeneration of cellulosic fibres can be segmented into two broad categories: those that are focusing on cotton waste and those that are separating the fibres from blended garments and producing two outputs – e.g. extracting both the polyester and cotton from a polycotton garment and valorising both outputs.

COTTON WASTE STREAM

Image courtesy of Evrnu

- Evrnu is a US-based textile innovations company creating circular solutions through a range of regenerative fibre technologies including cellulosics, regenerative polyester, recoverable stretch and bioengineered materials. In July 2019, Evrnu unveiled their collaboration with Stella McCartney and adidas, which incorporated their cellulosic NuCyl™ fibre (60%) blended with virgin cotton (40%). NuCycl™ technologies extend the life cycle of today's single-use textiles to help provide a powerful solution to the problem of textile waste.

- Finnish Infinited Fiber Company (IFC) was founded in 2016 to commercialise a breakthrough technology that enables cellulose-rich refuse – like pre- and post-consumer textile waste, used cardboard, and agricultural waste – to be regenerated into unique, high-quality, cotton-like fibres, known as cellulose carbamate fibres. Infinited Fiber Company's process is free of carbon disulphide (CS_2) and offers a sustainable and safe alternative to conventional viscose production. Instead of carbon disulphide, the technology uses urea - a safe and natural compound, giving the cotton-like cellulose carbamate fibres their unique characteristics, including their soft and natural look and feel. The Finnish company's technology is being scaled up with investments from major industry players such as H&M Group and RGE Group[52].

INFINITED FIBER COMPANY, WEEKDAY AND MAISIE WILLIAMS COLLABORATION

Creating beautiful denim clothes from 100% regenerated textiles is possible, as shown here by Game of Thrones star Maisie Williams. In 2019, IFC and Maisie Williams teamed up with H&M's Weekday brand to raise awareness of the need for circularity in fashion and to demonstrate what Infinited Fiber Company's technology enables. She and Weekday co-designed this unique denim outfit, made of 100% Infinited Fiber and produced completely from regenerated, post-consumer textile waste.

Image courtesy of Infinited Fiber Company

Closing The Loop

- Renewcell - founded in 2012, is a Swedish chemical recycler that turns cotton waste into dissolving pulp. They have the largest commercial production output of any of the innovators, with their Kristinehamn demonstration plant capable of producing around 7000 tonnes of pulp annually[53]. They have had significant traction with established upstream fibre manufacturers – partnering with Tangshan Sanyou and others[54]. Regarding brand engagement, Renewcell's Circulose® fibre featured in H&M's 2020 Conscious Exclusive campaign, and has recently announcing a collaboration with denim giant Levi's Strauss[55]. Renewcell's ambition is to grow its recycling capacity to 250,000 tonnes per year by 2026 and it counts H&M Group and KappAhl, another Swedish fashion brand, amongst its strategic investors.

RENEWCELL & LEVI'S
In July 2020, Renewcell announced their biggest collaboration to date, partnering with Levi's on their Wellthread line. The line of jeans, being described as Levi's 'most sustainable jean' ever, contain 40% Circulose® viscose staple fibre, blended with 60% virgin organic cotton[56]. The Circulose® fibre itself is comprised of 50% recycled cotton from post-consumer jeans and is blended with wood pulp from a CanopyStyle green shirt producer[57]. What is more, Levi's utilised a water-saving dyeing and finishing method, further improving the environmental impact of the denim.

Image courtesy of Renewcell

- Saxcell – a spin-off from the Saxion University of Applied Sciences in the Netherlands have developed a process that turns cotton textile waste into regenerated cellulosic pulp, which can then be spun into a new fibre using the viscose or lyocell process. They are currently increasing the production to 100 kilograms of pulp per day, which has been made possible through a recently signed shareholder agreement between three Turkish textile companies who will take ownership of the fibre, yarn and garment production steps of the supply chain[58].

Closing The Loop

BLENDED WASTE STREAM

The innovators concentrating on the blended waste stream are generally less technologically developed than other textile-to-textile recycling technologies. This is in part due to the challenge in separating the fibres from blended garments – leading to long R&D times as well as significant investment required. However, given its been estimated 40% of the textile waste stream is comprised of blended garments, they are tackling an immense problem with a huge opportunity to bring high-value recycled fibres to market at scale[59].

- Founded in 2018, Australia-based Blocktexx has developed a patent pending process that combines chemical recovery technology and advanced manufacturing to separate and recycle polyester and cotton blends. The company raised seed funding of over $500k in mid-2019, which enabled the optimisation of their technology in a pilot plant alongside trial projects with supply and demand partners[60].

- Phoenxt is a blend recycler with a vision to develop and commercialise its circular recycling technology, in order to offer an effective, sustainable, environmental solution. It uses an innovative proprietary chemical engineered process to separate and purify textile waste products, molecularly dissolve and reformulate into base polymer materials. Its fibre separation technology is solvent-free, and it focuses on blended fibres such as poly, cotton, and other plant base natural cellulosic fibres. Hence Phoenxt acts as a bridge between end-of-use cycle textiles and raw material supply, creating new materials from the existing waste without extracting more natural resource

- Tyton BioSciences developed a water-based hydrothermal solution to recycle cotton, polyester and polycotton blended fabrics. Their low impact process can separate polyester from cotton by breaking it down to its monomer building blocks so it can be remade into virgin polyester while maintaining the integrity of the cellulose for use in MMCFs as a virgin tree pulp substitute. Earlier this year, Tyton BioSciences closed an $8 million Series A round led by Tin Shed Ventures – the investment arm of apparel brand Patagonia – along with the major Japanese integrated trading and investment business conglomerate Marubeni, which will be used to accelerate their journey to commercialisation[61].

- Worn Again is a UK-based enhanced chemical recycling innovator that is working to recapture raw materials from non-reusable products through a proprietary solvent-based technology. Their unique polymer recycling technology is able to separate, decontaminate and extract polyester and cellulose (from cotton) from non-reusable textile to produce dual PET and cellulose outputs, therefore putting sustainable resources back into production supply chains. In January 2020, Worn Again announced the launch of their pilot R&D facility which will help to refine their technology and accelerate their journey to commercialisation[62]. This was further propelled when they received an additional €8 million investment in June 2020 from two of their existing strategic investors, H&M Group and industrial engineering firm Sulzer[63].

ALTERNATIVE NON-TEXTILE FEEDSTOCKS

As well as using cotton textiles as a feedstock for (regenerated) viscose production, innovation is emerging in the field of using agricultural by-products as alternative feedstocks.

- Algalife, founded in 2016, creates dyes and fibres from algae. The algae is blended with virgin wood pulp to create fibres and is a drop-in solution for spinners - meaning that minimal machinery adjustments should be required in the downstream supply chain. A 100% algae feedstock is in the research and development pipeline.

- The Dutch Inspidere have developed a method to convert cellulose from dairy cow manure into regenerative cellulose fibres, known as Mestic. In doing so, reliance on virgin resource input is reduced and contamination of nearby agricultural soils and waters are prevented[64]. Moreover, methane gas production is reduced as when not utilised, the decomposition of manure releases the harmful greenhouse gas into the environment.

- Another innovator addressing the issue is Orange Fiber – an Italian start-up utilising some of the 700,000 tonnes of citrus juice waste that is produced annually. They have created a patented process to extract the citrus cellulose from the orange peel (known as the pastazzo), to then be spun into a fibre comparable to MMCFs[65]. They have had significant industry traction; collaborating with the luxury Italian brand Salvatore Ferragamo's 2017 capsule collection and H&M in their conscious collection in 2019[66].

Image courtesy of Orange Fiber

- Publicly-listed Australian research and development company Nanollose are focused on discovering, developing and commercialising processes related to microbial nanocellulose. With their proprietary technology, they are able to turn biomass waste products from the food and beverage industry into microbial cellulose, which is then converted into rayon fibres using Nanollose technology.

NANOLLOSE AND BIRLA CELLULOSE

Birla Cellulose is exploring alternative feedstocks in cellulose production – with Birla Cellulose signing a collaborative agreement to become an industrial partner to the Australian innovator Nanollose[67].

The collaboration provides Nanollose with access to Birla's deep industry expertise and state-of-the-art facilities, accelerating the journey towards commercialisation. The long-term partnership will allow the optimisation and scaling of Nanollose's Tree-Free fibres – alleviating the burden on virgin raw materials[68].

Image courtesy of Nanollose

Closing The Loop

- Finnish innovator Spinnova have developed a technology that can turn pulp into textile fibre without regenerating or dissolving with harmful chemicals. Acknowledging the opportunity to turn waste produce into high value output, Spinnova have begun researching the possibility of using wheat straw as a feedstock to use in their mechanical process and have had initial successful lab scale trials. Spinnova have had significant traction with investors, recently closing an €11 million growth capital round from their existing investor base - which will be used to help scale their operations towards commercialisation[69].

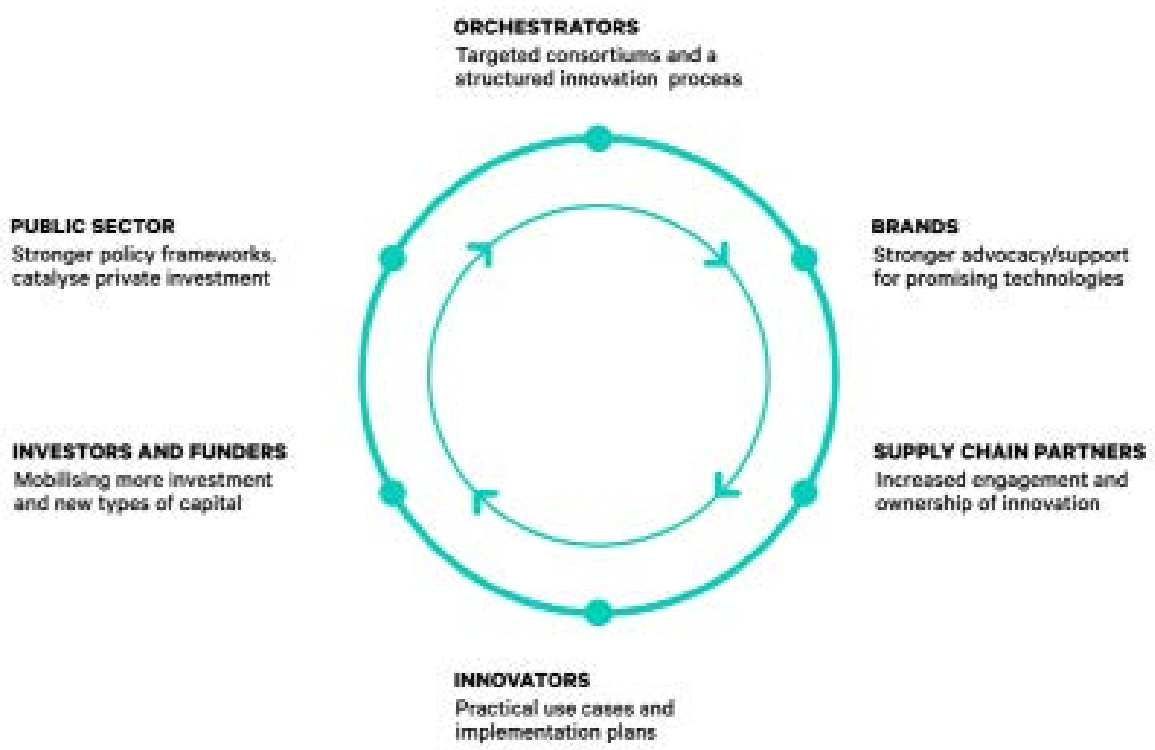
- The Hurd Co. is a US-based innovator that makes agrilose™: a MMCF feedstock pulp made entirely from post-harvest plant material. The company's patented technology works with multiple types of agricultural waste, and produces pulp that is compatible with existing extrusion methods. The lignin and sugar by-products are then used in the bioplastic and biofuels industry, increasing the circularity of the innovation, as well as recapturing and reusing 99% of the solvent used in the process.

The above examples of disruptive innovation replacing the use of virgin wood feedstock in MMCF production are critical in achieving greater circularity in the industry; however, these examples cannot operate in silos. They are reliant on full collaboration and cooperation from the industry – with some of the most successful implementation examples being achieved when tackled by multiple stakeholders. The multi-stakeholder consortium structure is necessary to create harmonised industry buy-in and thus facilitating the next evolution of closed-loop production in the MMCF industry.

> **"Chemical recycling faces multiple barriers to scale and industry adoption; a key barrier being risk-tolerant investment for innovations that can enable testing, refinement and scale. We hope that our investment in the Full Circle Textiles Project will enable wider adoption and catalytic investment across the industry to map the course of change together."**
>
> Anita Chester, Head of Materials, Laudes Foundation (formerly C&A Foundation)

7 Scaling Up
Consortium projects enable innovation to scale

The current fragmented ecosystem of brands, upstream manufacturers and innovators is inefficiently connected and requires greater orchestration to create a marketplace more ready for innovation. Targeted consortium projects and the parties within have the power to convene, accelerate progress and transition from siloed success stories to systemic change[70]. A recent BCG and Fashion for Good (2020) report outlined the importance of consortium projects in scaling innovation within the fashion industry. The report highlighted several key stakeholders within the consortium group; Orchestrators, Brands, Supply chain partners, Innovators, Investors and the public sector[71]. This sentiment was echoed within the MMCF industry; with Textile Exchange and Forum for the Future highlighting collaboration across the whole supply chain as a key enabler in the transition to a more sustainable and circular industry[72].



The orchestrators play a pivotal role as no single stakeholder operating on their own can provide all the capabilities and expertise necessary to scale innovation. Moreover, orchestrators such as Fashion for Good ensure a structured and streamlined approach to innovation; providing ecosystem-level coordination across different stakeholders and micro-level support to specific innovators. Bringing structure to the innovation process between brands and innovators brings significant benefits, providing brands with predictability through clear gate-stages of technological innovation, as well as allowing greater comparability across innovators to assess the difference in technology and output. On the other hand, innovators are better able to understand the processes and competencies required to help bring new technology to market at scale.

Scaling Up

Brands have an important role to play in overcoming the barriers to scale innovation, many of which can be prevailed through collaboration with innovators and other stakeholders. Through consortium projects, brands are able to share their invaluable industry and technological expertise and help innovators to develop, therefore maximising the chance of commercialisation. The co-development process is a win-win for both innovators and brands; brands position themselves at the forefront of innovation whilst innovators can optimise their technology to brand's needs and thus catalyse their growth.

Given the importance of upstream manufacturers in the value chain, it is imperative that they are engaged in collaborative activities with brands and innovators alike. In doing so, manufacturers can share their technological and industry expertise and provide access to essential facilities to enable innovators to validate their product. This provides a unique opportunity to partner with and assist innovators through the challenging research and development phase on the path to commercialisation.

Through exposure to collaborative projects, innovators can better hone in on the use case of their technology – moving from the ideation phase to a marketable implementable plan. Industry exposure forces innovators to think more prudently about their business plans, refine their value proposition dependent on industry demand and more effectively partner with the established players in the industry.

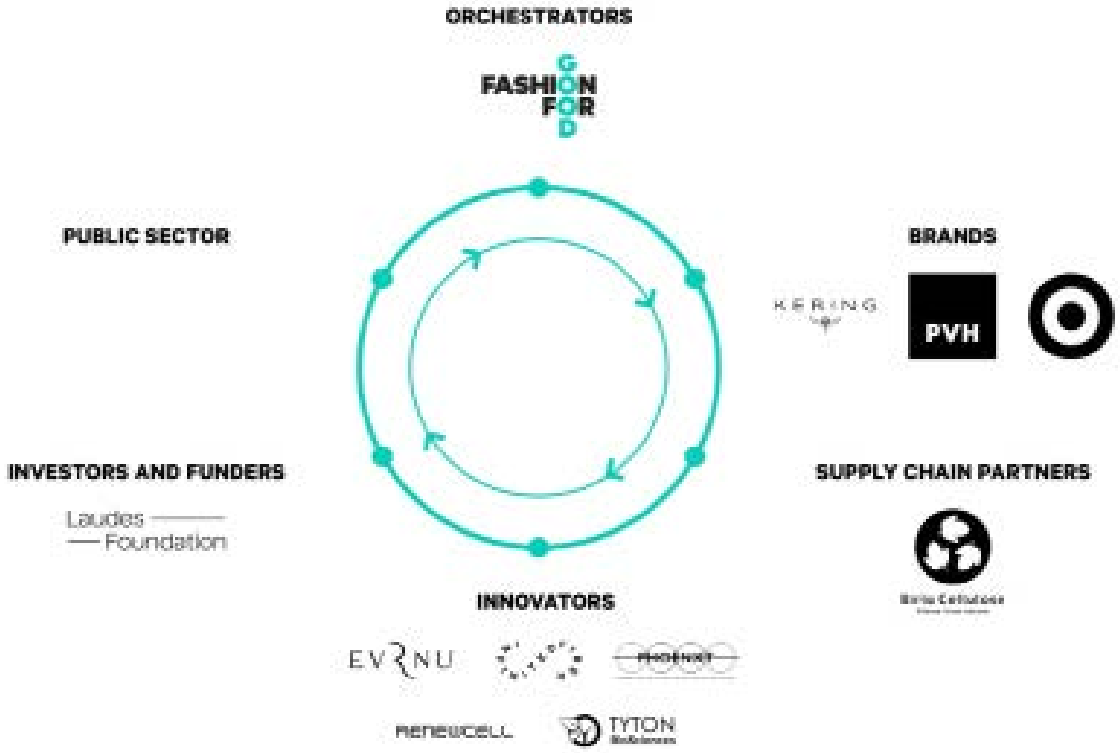
Financiers and the investor community bring key expertise beyond the obvious financial support needed to scale innovation. Investors can play a role in advising and connecting entrepreneurs to the wider investment community – bringing with it a network of support, coaching and expertise that is essential to accelerating innovation. There are a variety of funding mechanisms available to innovators at different stages of maturity, including: venture capital, blended finance, traditional debt financing and philanthropic capital. It is crucial that this array of investors and lenders are engaged in the fashion innovation space, as no one segment will be able to provide the level of funding and expertise required to finance a more sustainable industry.

The public sector plays a significant role as both a means to empower systemic change as well as catalysing further investment. Establishing a policy framework consisting of regulations, standards and economic incentives that encourage more sustainable practices will put pressure on the industry to accelerate innovative solutions and transition to a more sustainable industry. Moreover, looking aside to other industries has shown that public sector investment in innovative SMEs helps to unlock greater levels of private sector capital – for example, each €1 that EU's Horizon 2020 invested generated €1.6 of private investment[73].

Addressing the problems presented in this report is no different from other innovation challenges – therefore a consortium group is an appropriate structure to tackle key issues and move the needle towards closed loop MMCF production. Fashion for Good have put this strategy to action with the launch and implementation of their consortium Full Circle Textiles Project. This consortium structure will allow participants to focus on their speciality, mitigate risks and benefit from shared learnings, thereby accelerating the transition to a more circular MMCF industry through increased rates of textile-to-textile recycling.

8 Taking Action
The Full Circle Textiles Project

The aim of the Full Circle Textiles Project is to address the first two problems highlighted in Chapter 3 in this report – that is reducing the amount of textiles going to waste whilst simultaneously alleviating the resource strain on virgin materials through the recycling of used textiles.



Building off the findings of the BCG and Fashion for Good report as introduced above, the Full Circle Textiles Project aims to bring together a consortium of relevant stakeholders required to demonstrate the viability of the innovative technologies and enable these solutions to scale. Fashion for Good plays the role of the orchestrator; bringing together a targeted consortium of four of these stakeholders whilst laying the foundation for a structured innovation process. Brand partners, Kering and PVH Corp. bring hands-on operational support to the project in the production of finished garments, with themselves and Target also providing financial support for the most promising technologies. Laudes Foundation are too providing financial support, thus facilitating equal financial opportunity for the innovators participating. Upstream supply chain partner, Birla Cellulose will be responsible for the conversion of cellulosic pulp made from recycled textile waste to fibre and subsequent testing - providing valuable industry expertise to the innovators. Birla Cellulose will also work closely with the innovators to optimise the recycled content in the fibre.

BIRLA CELLULOSE'S COMMITMENT TO SUSTAINABILITY AND INNOVATION
Birla Cellulose make for a suitable supply chain partner for four key reasons:

1. **Strong focus on R&D and lab scale pilots plants - Their lab scale, kilo scale and ton scale pilot facilities are well suited to test small amounts of output, giving innovators the ability to refine their offering and receive feedback**
2. **Experience in developing their own cotton recycling technology provides expertise to accelerate project progress.**
3. **Commitment to sustainability, including chemical and wastewater management - Their Nagda plant is in the process of becoming the first Zero Liquid Discharge viscose fibre plant - recovering 96% of the wastewater feed. Birla Cellulose have also committed $170 million towards upgrading closed loop technologies across its global sites in order to meet EU BAT requirements and ZDHC guidelines by 2022[74].**
4. **Commitment to responsible forestry practices - Birla Cellulose achieved low risk on their CanopyStyle audit for sourcing from ancient and endangered forests and a 'green shirt' in the 2019 Hot Button Ranking (see page 10 for explanation).**

On the innovator side, selected chemical recycling innovators are responsible for demonstrating that their product can meet industry requirement's in both a qualitative and quantitative way. The participating innovators are as follows Evrnu, Infinited Fiber Company, Phoenxt, Renewcell and Tyton BioSciences.

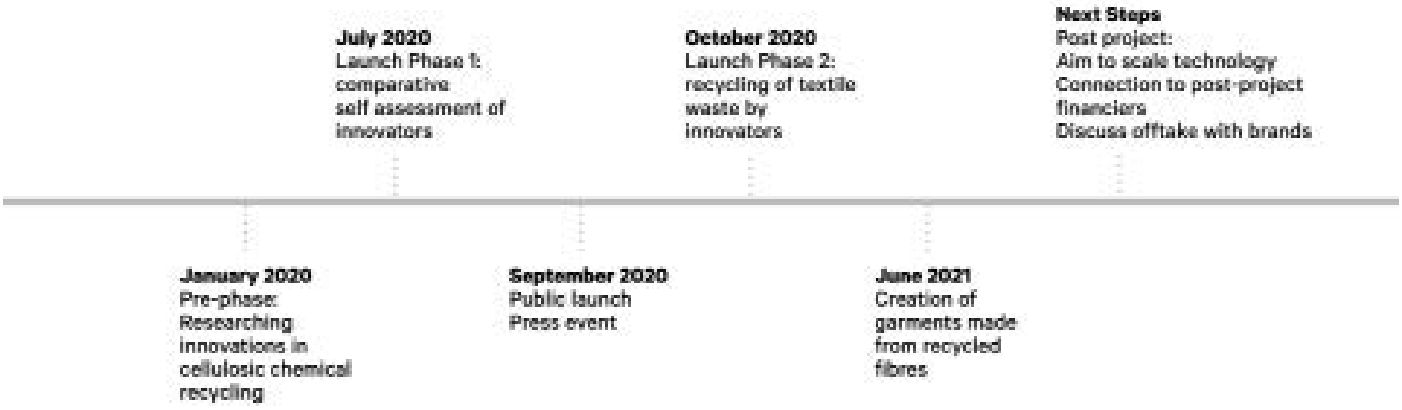
> **"The need of the hour is to co-create sustainable solutions for the fashion industry that can be scaled rapidly and economically."**
>
> Mr. Dilip Gaur, Business Director, Birla Cellulose, Aditya Birla Group

Taking Action

PROJECT STRUCTURE

The Full Circle Textiles Project was initiated in January 2020 with the focus on scouting and researching all innovation globally able to conduct cellulosic textile-to-textile chemical recycling. Simultaneously the consortium group was gathered with key roles and responsibilities within the project being established. Thereafter the project structure was formulated, and the group mobilised for phases one and two.

The first part of the Full Circle Textiles Project aims to provide a comparative assessment between the different innovators. Due to the complexity of the technology, and the existing lack of structure to assessing innovation as mentioned previously, it is challenging to decipher which technologies to support and assist in scaling in the long term. In order to achieve this, a group of selected innovators will be invited to take part in a self-assessment process that will serve as a comparative due-diligence. The assessment is focused on five key areas; the environmental impact of the technology, the input/feedstock required, the output, the company structure as well as the technology and any associated risks to scaling.



The second part of the Full Circle Textiles Project moves from assessment to implementation; with a select number of innovators being invited from Phase 1 to produce cellulosic output from waste textiles that will be processed into fibres, yarns and eventually end garments for participating brand partners Kering and PVH Corp. This will provide innovators with the opportunity to validate their technology with established supply chain partners, as well as provide brands the ability to pioneer the integration of recycled textiles into their production. Moreover, by involving an upstream manufacturing partner in the conversion of cellulosic pulp to fibre, the Full Circle Textiles Project aims to initiate long-standing partnerships and knowledge sharing between the different stakeholders.

The completion of the second phase will signal project close and a report outlining the key learnings will be published to be utilised and shared across the industry and consumers alike. Whilst the Full Circle Textiles Project formally ends at that point, the aspiration is for these learnings to be adopted by other industry stakeholders to accelerate scaling of these technologies. Once the innovators' output has been validated by established industry players, this should help to de-risk the perception of the technology, thus mobilising and unlocking more investment in these disruptive chemical recycling solutions. The extensive assessment of innovation in both phases one and two above should lead to further offtake agreements from the brands, which is essential to signalling demand to investors, further stimulating investment. The project structure has been formulated to place the innovators in the best position to enable action to scale.

9 Catalysing Transformation

An industry-wide call to action

The MMCF industry currently stands at a critical inflection point; without immediate action the continued irresponsible logging of forests and discharge of hazardous chemicals will damage ecosystems, threaten livelihoods and have irreversible effects on our climate. Having said that, when approached with a path to conserving ancient and endangered forests and circularity in alternative fibre sourcing, MMCF provides an opportunity to divest from oil-derived polyester and water-depleting cotton. Visions for this future system are emerging and initial steps have been taken – mission-driven expert organisations are paving the way for the wider industry to follow. Central to that journey is the scaling of innovation in textile-to-textile recycling. Through this technology, there lies the ability to transform existing textile waste into regenerated fibres of virgin-like quality. This reveals a unique possibility to tackle two of the problem areas with one stone; alleviating the reliance on virgin input and reducing the amount of textile waste being sent to landfill/incineration.

The promising innovation in chemical recycling of textiles is emerging and growing in significance; however, it cannot operate as siloed success stories. More needs to be done to engage the wider industry and move the needle towards a more circular industry. The Full Circle Textiles Project aims to bring together relevant stakeholders within a consortium to provide structure to the innovation process, whilst giving innovators an opportunity to refine their offering through industry support and expertise. Whilst the aspiration for the Full Circle Textiles Project is to enable scaling of the cellulosics chemical recycling industry, it is clear that such a large endeavour cannot be achieved by one consortium project alone.

A concerted, industry-wide effort is required to provide the incentive and financial means needed to accelerate the transformation to sustainable and closed-loop processes. Fashion for Good, through the Full Circle Textiles Project, hopes to inspire other stakeholders to pilot, invest and ultimately secure offtake with chemical recycling innovators, thus catalysing the transformation to a truly circular economy.

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