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Recycled Textile Fibres and Textile Recycling

An overview of the Market and its possibilities
for Public Procurers in Switzerland

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A full list of stakeholders who contributed to this report is available in Annex 1.

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Executive summary

Facing the reality that resources will increasingly become scarce and that the population will continue to grow, the textile industry is considering and working on recycled fibres, textile-to-textile recycling and end-of-life solutions as a way to reduce the industry's overall environmental impact. This study, commissioned by the Swiss Federal Office for the Environment (FOEN), has two objectives: (a) to give a glimpse of the current state of the market of recycled fibres, including its use in professional wear and (b) to issue recommendations to encourage the procurement of textiles with recycled content and consider end-of-life solutions for professional wear in Switzerland.

Key aspects of the discussion on recycled fibres and textile-to-textile recycling are summarised below:

Technical innovation:

Many innovations are currently taking place in the recycling of textiles, mainly in the chemical recycling as this is more likely to keep the quality of the fibre and achieve the separation of material blends (polyester/cotton for example).

Current status:

Most innovations are in development: economical and technological viability to be able to scale up to an industrial level still needs to be proven.

Scientific knowledge:

Scientific knowledge on the impact of recycled fibres is limited because the textile supply chain is vast and complex. This means that the impact depends on many factors to be taken into consideration (no one size fits all).

Outlook:

The industry of recycled fibres and textile recyclability will pick up in the coming 5 to 10 years provided there is demand, drive and collaboration between supply chain actors.

Needs to get there:

- New ways of doing business, disruption, putting a price on externalities (i.e. the real price of a raw material).
- Essential dialogue and collaboration between different market actors.
- More investments and access to financial mechanisms.

Today, the market of professional wear can offer textiles made of recycled fibres, mainly recycled polyester from PET bottles. Key challenges identified by suppliers are (a) the price, which is still higher for recycled fibres and professional wear is a price sensitive sector; (b)

high product standards, which makes certain recycled fibres more challenging to use due to quality issues; (c) recyclability, because of potential chemical residues from previous treatments and the dirtiness of professional wear (e.g. Personal Protective Equipment).

In Switzerland, some public companies have started procuring textiles with recycled content but it remains marginal. The biggest challenge is that public procurers have little insight into the market, preventing them from including the requirement for recycled fibres in their tenders. Suppliers, on the other hand, are waiting for a clear signal from procurers, which would give them the assurance they need to further invest in the field. A dialogue between public procurers and suppliers outside tendering procedures is thus highly recommended. Beyond this, public procurers can already use different tools to include requirements for recycled fibres in their tenders, such as the updated EU Green Public Procurement criteria on textiles, which address recycled content and end-of-life solutions. On the end-of-life discussion, Swiss public procurers are not aware of end-of-life solutions for their professional wear. Some have taken the lead and implemented their own solutions, mainly through charities and recyclers. The recommendation would be to further investigate end-of-life solutions for professional wear in Switzerland in order to determine the needs, opportunities and challenges that will help consider and develop common solutions.

Introduction

By 2030, it is projected that overall consumption of textiles will have risen by 63%, from 62 million tons today to 102 million tons¹. The textile industry's current linear model of make, use and dispose of represents an obvious stress on natural resources². Globally, only 13% of used garments are collected, leaving a staggering 87% of all end-of-use textiles going to landfill and incineration³. For professional wear, which is the focus of this study, incineration is the main treatment of textiles at the end of life (for example an estimated 90% in 2012 in the United Kingdom⁴).

Recently, a trend has been developing moving away from this unsustainable linear model towards a more circular one, applying the concept of circularity or circular economy. This is based on three principles: phase out waste and pollution through design, keep products and materials in use and regenerate natural systems⁵.

This study, commissioned by the Swiss Federal Office for the Environment (FOEN), has two objectives. The first objective is to give a glimpse of the current state of the market of recycled fibres, including a general overview of professional wear. The second objective is to issue recommendations to encourage the procurement of textiles with recycled content and to consider end-of-life solutions for professional wear in Switzerland.

Chapter 1 gives an overview of recycled fibres by reviewing the recycling processes, the ecological advantages of these recycled fibres and the difference in quality compared to virgin fibres. Chapter 2 examines the current offer of professional wear using recycled fibres and discusses some of the challenges voiced by supply chain actors. Chapter 3 looks towards the future at the innovations taking place in the field and their potential. In chapter 4, case studies of other countries' use of and approach to recycled textiles and recyclability are outlined. Finally, in chapter 5, the study gives recommendations to Swiss public procurers for sourcing professional wear with recycled content and shows that more research needs to be done for professional wear end of life solutions.

¹ Global Fashion Agenda & The Boston Consulting Group, *The Pulse of the Fashion Industry* (2017), 8, http://globalfashionagenda.com/wp-content/uploads/2017/05/Pulse-of-the-Fashion-Industry_2017.pdf.

² See Annex 2.

³ Ellen Mc Arthur Foundation and Circular Fibers Initiative, *A new Textiles Economy: Redesigning Fashion's Future* (2017), 91, https://www.ellenmacarthurfoundation.org/assets/downloads/publications/A-New-Textiles-Economy_Full-Report.pdf.

⁴ European Textiles & Workwear Market, *The Role of Public Procurement in Making Textiles Circular*, 5, <https://www.pianoo.nl/sites/default/files/documents/documents/ecapworkwearreport-maart2017.pdf>.

⁵ Ellen Mc Arthur Foundation and Circular Fibers Initiative (2017), *A new Textiles Economy*, 48

Scope

The prime focus of this study is textile-to-textile recycling (or closed loop recycling) which today represents less than 1% of the material used to produce clothing⁶. This study also considers a wider concept, named ‘the circular economy’, which is increasingly gaining traction in all sectors and can be defined as follows (see Annex 3 for a graphic representation):

“A circular economy is one that is restorative and regenerative by design, and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles”⁷.

In a circular economy, “the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste is minimised”⁸.

Methodology

Due to the complexity of the topic and the textile industry in general and the lack of quantitative data available on the topic, the methodology used in this report combines a literature review with qualitative research methods (mainly formal and informal interviews). This research project thus gives an initial overview of the market situation and status to public procurers but is not meant to be comprehensive.

⁶ Ellen Mc Arthur Foundation and Circular Fibers Initiative, 2017. *A new Textiles Economy*, 20.

⁷ Ellen MacArthur Foundation, 2015. Circular Economy. www.ellenmacarthurfoundation.org/circular-economy

⁸ European Commission, 2015. *Closing the loop – An EU action plan for the Circular Economy*, COM(2015) 614/2, Brussels

1. Recycled fibres: an overview

This first section gives an overview of the recycling processes of different fibres, the quality level of recycled fibres versus virgin fibres, the ecological advantages of recycled fibres and the role of product development in encouraging the recyclability of the product.

1.1. Background

The global fibre market is overwhelmingly dominated by two fibres: polyester and cotton (82%⁹). The use of synthetic fibres, especially polyester, continues to rise. Polyester currently represents more than half of the global fibre use:

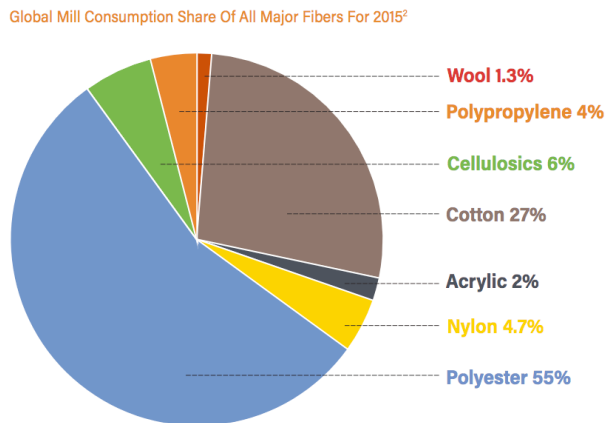


Figure 1: Global consumption of all major fibres in 2015¹⁰.

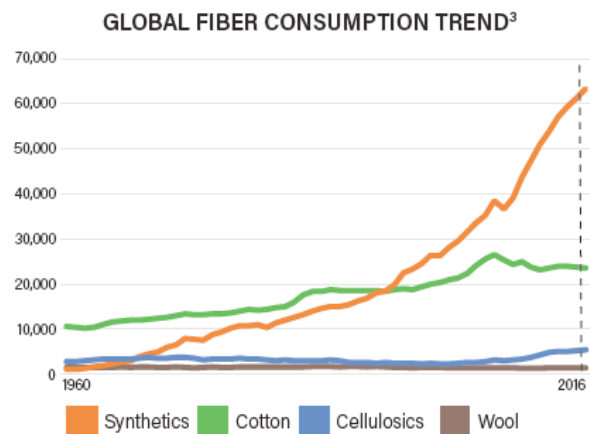


Figure 2: Global fibre consumption trend from 1960 to 2016¹¹

⁹ Textile Exchange Preferred Fibre Materials Market Report, 2016.

¹⁰ Textile Exchange Preferred Fibre Materials Market Report, 2016.

¹¹ Textile Exchange Preferred Fibre Materials Market Report, 2017.

Textile waste can be classified in two categories:

- Pre-consumer textile waste or industrial waste resulting from fibre processing or taking place during the production of textiles. 75% of pre-consumer textile waste is diverted from landfill and recycled¹² into raw materials for industries like the automobile industry, insulation or mattresses.
- Post-consumer textile waste comes from any textile or household textile article that consumers no longer want. Some of this waste is collected for a second life - usually in the form of reselling / downcycling - or for incineration. The presence of fibre blends (polyester/cotton, for example), dyes and all types of accessories in the recovered textile makes textile-to-textile recycling very complex and costly.

There are two main ways to recycle:

Mechanical recycling	Chemical recycling
Mechanical recycling is mainly about shredding the material to turn it into a near-fibrous form. Through this process, the fibre can lose its strength and thus needs to be mixed with virgin fibre (especially in the case of cotton and wool). This process has been used for many years.	Chemical recycling involves a chemical process in order to retrieve the wanted raw material. It allows the recovery of more a valuable product and currently shows promising technological innovation. Although the industry is actively working on this kind of recycling, it is not yet technologically or economically mature. ¹³

Table 1: Two main ways of recycling: mechanical and chemical recycling

1.2. Recycling processes per fibre

Recycling processes vary per fibre, as shown in the following table:

Fibre	Material input	Mechanical recycling process	Chemical recycling process
Polyester	Polyethylene terephthalate (PET), approximately 95% of which comes from PET bottle recycling. Recycled polyester represents about 7% of all the virgin polyester production ¹⁴ .	Plastic PET containers are sorted by type and colour. The labels are then removed and the bottle is washed, crushed and chopped into flakes. The flakes are dried out and sent through a rotating screw, which heats the flakes to 220 degrees. It then enters a canal and emerges on the other side as fine long threads, which are then further processed into yarns. See Annex 4.	The material is first depolymerised to a base-chemical molecule called monomer and then re-polymerised with the help of chemical additives (typically methanolysis, glycolysis or hydrolysis) before being extruded into chips.
Nylon / Polyamide	As different types of nylon exist, the input has to be relatively homogenous waste	This is typically done with post-industrial nylon waste. The nylon is cleaned and	A polymer is chemically de-polymerised and broken down into its

¹² H.-L. Chen and L.D. Burns, "Environmental Analysis of Textile products," *Clothing & Textiles Research Journal* 24 no. 3 (2006): 256.

¹³ Ellen Mc Arthur Foundation and Circular Fibers Initiative, 2017, *A new Textiles Economy*, 91.

¹⁴ *Textile Exchange Preferred Fibre Materials Market Report*, 2017.

	material: e.g. nylon, old fishing nets, waste and scraps from virgin nylon production and textiles provided they are the same nylon type ¹⁵ .	then simply pelletised for further use.	monomer components. It is then re-polymerised to make a new yarn.
Cotton	The input material is any cotton garment.	Mechanical recycling of cotton is the most established recycling process, but still represents only a small percentage in volume. It consists of separating the waste by colour and then shredding it before it is re-spun into new yarns.	Chemical recycling of cotton is currently still at lab level but shows promising innovative development where for example the cotton is retrieved from post-consumer waste garments and dissolved to a molecular level. From there, it becomes a dissolving pulp to make viscose and lyocell products.
Wool	The input material is mainly pre-consumer wool waste.	Wool has been recycled commercially for at least 200 years ¹⁶ . It consists in separating the waste by colour and then pulling the garment back into a fibrous state to make new products.	This process is not done today.

Table 2: Description of the recycling process per fiber

1.3. Ecological advantages of recycled fibres versus virgin fibres

The ecological advantages of recycled fibres versus virgin fibres differ per type of fibre but also within the same fibre depending on the origin and the recycling process. Quantitative data is not readily available and this lack remains an important point of discussion in the industry. More solid and scientific based data is needed to make informed decisions. Some organisations have set out to fill the gap. A Consortium led by Quantis is building up the World Apparel & Footwear Life Cycle Assessment Database, which is meant to provide specific data based on reliable life cycle assessments¹⁷. The Higg Materials Sustainability Index (Higg MSI) is a material scoring tool from the Sustainable Apparel Coalition that measures the environmental performance of thousands of materials used in creating apparel, footwear and home textile products¹⁸.

MADE-BY, a not-for-profit organisation specialising in sustainability in textiles, developed a benchmark in 2009 to compare the environmental impact of the most commonly used fibres in the garment industry. Although this benchmark has been criticised for being an oversimplification of a complex topic (e.g. the environmental impact of a fibre depends on so

¹⁵ *Textile Exchange Material Snapshot*, <http://textileexchange.org/downloads/material-snapshot-recycled-nylon-6/>

¹⁶ S. Russell, P. Swan, M. Trebowicz, and A. Ireland, "Review of Wool Recycling and Reuse," in *Natural Fibres: Advances in Science and Technology Towards Industrial Applications*, ed. R. Figueiro and S. Rana (Dordrecht: Springer Netherlands, 2016), 415-428. doi:10.1007/978-94-017-7515-1_33.

¹⁷ Quantis website: <https://quantis-intl.com/tools/databases/waldb-apparel-footwear/>

¹⁸ HIGG MSI Website: <http://msi.higg.org/page/msi-home>

many parameters: country of origin, irrigation used, actual supply chain) leading to a biased classification, it has the merit of being open source and providing a first glimpse into the environmental impact of different fibres (this benchmark is planned to be updated in 2018)¹⁹:

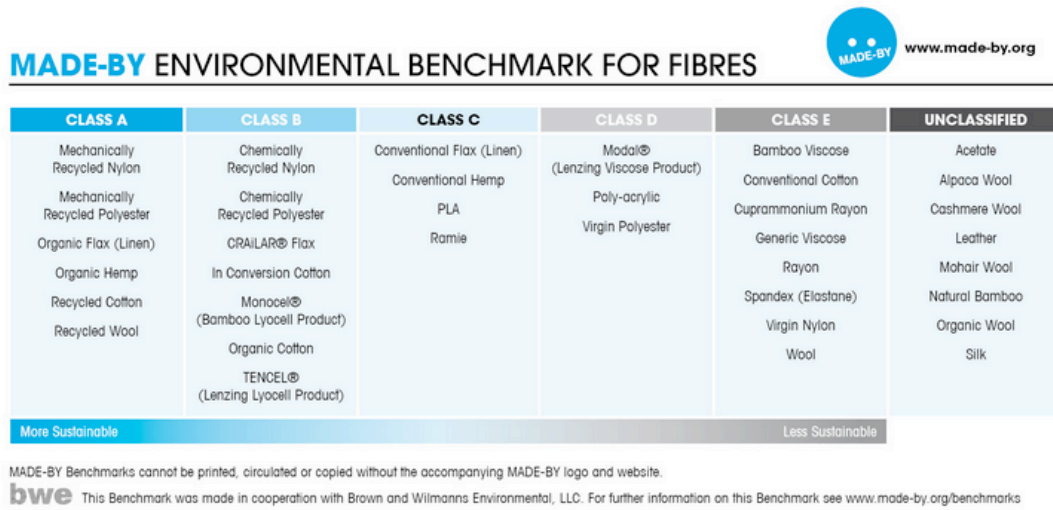


Figure 3: Made-By Environmental Benchmark for Fibers²⁰

Beyond this benchmark, the general ecological advantages of recycled fibers versus virgin fibers can be summarised as follows²¹:

¹⁹ The benchmark takes into account the production process of natural fibres and artificial fibres from the origin of the raw material to fibres ready to be spun. The unit of comparison is 1 kg of fibre ready to be spun. This is an average, so the rankings should be considered approximate. The impact parameters were defined as greenhouse gas emissions, eco toxicity and human toxicity (allocated a weight of 20% each), and energy input, water input and land use (allocated a weight of 13.33% each).

²⁰ <http://www.made-by.org/consultancy/tools/environmental/>

²¹ Data gathered through the Textile Exchange Material Snapshots except if mentioned otherwise: <https://textileexchange.org/publications/>

Fibre	Recycled Polyester	Recycled nylon	Recycled cotton	Recycled wool
Land use	No land use as input material already exists.			
Water Intensity	Both recycled and virgin polyester have a low water use so there is effectively no difference ²² .	Both recycled and virgin nylon have a low water use so there is effectively no difference ²³ .	Low water use in the recycling process and low impact compared to growing cotton, which needs 2700 litres ²⁴ to make one cotton tee-shirt.	Low water use in the recycling process.
Chemistry	For mechanically recycled polyester, no chemistry is used other than detergents for cleaning the input material.	For mechanically recycled nylon, no chemistry is used. Chemically recycled nylon uses high temperature, high pressure and a common chemical for the process ²⁵ .	Fewer chemicals are used than in conventional cotton as recycling does not include any farming operations.	Recycled wool requires fewer chemicals than conventional wool as neither farming nor scouring are required.
Energy	Recycled polyester uses 59% less energy than virgin polyester.	For example, the ECONYL (R) Chemically regenerated nylon uses 60% less energy than virgin nylon. ²⁶	Energy requirements are almost 20% lower for recycled cotton than for conventional cotton.	Energy requirement are lower for recycled wool.
CO2 emissions	Recycled polyester reduces emissions by 32% compared to virgin polyester ²⁷ .	Recycled nylon reduces emissions by 26% compared to virgin nylon ²⁸ .	By replacing the need for farming and avoiding the use of synthetic agrochemicals, emissions are minimised.	By replacing the need for farming and hence avoiding the emissions of methane during the animal's digestive process and the use of agrochemicals, emissions are minimized.

Table 3: Overview of the ecological advantages of recycled fibres versus virgin fibres

In addition, it can be said that recycled fibers: (a) conserve non-renewable resources by replacing the need for virgin materials; (b) divert waste from landfill by giving a second life to the garment and (c) in general, the recycling process asks for less primary energy and waste and has a lower climate impact than virgin fibres. Yet, some voices express skepticism towards the calculation methods because the impact of the fiber's first life is not included in the overall environmental assessment of recycled fibers. If it would, the results could differ.

²² WRAP (2017) in personal correspondence with reference to the footprint calculator used for the Sustainable Clothing Action Plan <http://www.wrap.org.uk/sustainable-textiles/scap>

²³ WRAP (2017) in personal correspondence with reference to the footprint calculator used for the Sustainable Clothing Action Plan <http://www.wrap.org.uk/sustainable-textiles/scap>

²⁴ WWF website: <https://www.worldwildlife.org/stories/the-impact-of-a-cotton-t-shirt#>

²⁵ Aquafil (2017), in personal correspondence.

²⁶ Aquafil (2017), based on Econyl's life cycle assessment.

²⁷ WRAP (2017) in personal correspondence with reference to the footprint calculator used for the Sustainable Clothing Action Plan <http://www.wrap.org.uk/sustainable-textiles/scap>

²⁸ WRAP (2017) in personal correspondence with reference to the footprint calculator used for the Sustainable Clothing Action Plan <http://www.wrap.org.uk/sustainable-textiles/scap>

1.4. Quality level of recycled fibres versus virgin fibres

Since the recycling process entails a breaking down process, the quality of the recycled fibre differs depending on the fibre and the recycling process used. Depending on the fibre, it will have to be mixed with virgin fibres in order to achieve the required material property and performance. The table below gives more information per fibre:

Fibre Type	General description	Mechanical recycling	Chemical recycling
Recycled polyester	Depending on the application, the material properties of recycled polyester can be similar to virgin polyester if purity of the input (e.g. the purity and colour of the PET bottles) is given.	Can only be done a few times before the molecular structure breaks down and makes the yarn no longer solid.	The quality of virgin polyester can be achieved and it can be recycled several times. But this process is still costly and not yet widespread.
Recycled nylon/polyamide	The material properties of recycled polyamide/nylon can be similar to virgin fibres, yet the process is more difficult and the input usually not ideal for recycling (too many different nylon types).	Hardly done in the industry. Some companies like Unifi recycle post-industrial nylon waste.	High quality due to technical advancement and expertise. It can be recycled several times. Only a few suppliers offer this making it rather costly.
Recycled cotton	Because of the dyestuff in most products, the mechanical recycling process results in a colour mix that is difficult to work with.	The fibre breaks and the quality of the yarn is thus not equal to that of virgin yarn. It usually needs blends with a majority of virgin or other material. No full colour and yarn flexibility.	Cotton can be a feedstock for the viscose or lyocell process. Especially the lyocell process can reach a high quality.
Recycled wool	Recycling of wool has been an established industry for a long time. The process is purely mechanical.	Recycled wool has shorter staple length (except for wool that is recycled for the first time ²⁹) than virgin wool. It needs to be blended with a maximum recycled wool content of around 70%. Limited colour and yarn options.	N/A

Table 4: Overview of the quality of recycled fibres versus virgin fibers³⁰

1.5. Role of product development to encourage recyclability

Today, product development mainly focuses on design aspects such as the look, feel, comfort and durability of the product to be procured. Not much thought is given to what should happen to the product when it reaches its end of life. Yet, this consideration should start at the very beginning of design/product development. The objective should be to not only take into

²⁹ Cardato Recycled: <http://www.3cfilati.it/en/portfolios/cardato-recycled-by-3c-filati/>

³⁰ Information based on the Textile Exchange Material snapshots and informal industry expert interviews as information is not readily available.

account the need to be fulfilled by the procurement, but also to consider the following design strategies:

- ✓ Design for disassembly is a design strategy that considers the future need to disassemble a product for recycling (e.g. dissolvable yarn, removable zipper or buttons, pull-off labels, etc). An example of this is Wear2, which is a unique yarn that is specially designed to weaken when put into a particular microwave treatment. This special yarn makes it easy to remove logos, zippers, etc. in order to enable reuse of the garment³¹.
- ✓ Design for RRR (Re-use, Re-pair, Re-cycle):

Re-Use	Re-Pair	Re-Cycle
The most environmentally friendly approach for end of life is the transfer of a product to a second life, either through donation or reselling. However, this is challenging when it comes to professional wear, because it is difficult to re-use due to logos and security concerns.	The possibility of repairing something can be considered at the design stage. Knowing the exact requirements and needs during the use of the product allows for designs that can be repaired once or several times. Especially high-value products such as jackets, tents and shoes should be considered, so that they do not have to be replaced but can be repaired.	Products are designed so that the whole or individual components (once disassembled) can either be recycled as technical parts or biodegraded into organic matter. Products for recycling should be produced without hazardous chemicals and substances to enable safe industrial recycling or safe biodegradation E.g. antimony-free polyester allows ongoing recycling.

Table 5: Description of Design for Re-Use, Re-Pair and Re-Cycle

- ✓ Mono-materiality can be considered the ideal product concept for recyclability. The whole product is made from one material, for example polyester used for main material, trims, threads and labels. Once this product enters the recycling stream (and it is known or marked as such), it can be mechanically or chemically recycled without waste, extra handling, time or cost. Yet most of the textile in professional wear is blended. In this case, for easier recyclability, it is recommended to (a) develop textiles with one dominant fabric (at least 80%) (b) use fibre types that have better recyclability profiles (polyester or nylon 6 for example) and (c) reduce the different types of materials without sacrificing the functional performance.³²

³¹ Wear2 website: <http://wear2.com/>.

³² Greenblue, *Chemical recycling, Making Fiber to Fiber Recycling a Reality for Polyester Textiles*, 2017, 19: <http://greenblueorg.s3.amazonaws.com/smm/wp-content/uploads/2017/10/Chemical-Recycling-Making-Fiber-to-Fiber-Recycling-a-Reality-for-Polyester-Textiles-1.pdf>

2. Professional wear and recycled fibres

It is estimated that some 93,000 tons of professional wear were consumed in 2015 in Europe. More than 8.6 billion euros were spent on the procurement of public sector professional wear³³. This represents a significant purchasing power, about 15% of the GDP in Europe. This sector is therefore instrumental in encouraging the market of recycled fibres.

2.1. Classification of professional wear

No formal classification of professional wear exists. As a result, the below classification has been defined for the purpose of this study³⁴:

- **Workwear:** Garments for manual work including overalls, coats, jackets, trousers, similar styles also used in the catering and wholesale/distribution sectors: usually a polyester / cotton blend.
- **Career wear:** Garments used to project a corporate identity. Examples are administrations, post offices, hotels, schools, caterers. Mostly cotton, cotton blended with synthetics, wool or wool blends.
- **Uniforms:** used in the police, military: mostly in wool, or wool blended with synthetics.
- **Personal Protective Equipment (PPE)** refers to equipment that protects the user from injury or infection. Usually this equipment needs to comply with EU standards: mostly polyester or blends with special protection fibres, fabrics are either treated or laminated.

More information on typical composition of different professional wear is available in Annex 5.

2.2. Professional wear with recycled fibres

Similar to the fashion market, the offer of professional wear containing recycled fibres is still limited. Based on several interviews with industry actors, recycled polyester made of PET bottles is beginning to be most commonly available. See below for a general overview of the market³⁵.

³³ European Textiles & Workwear Market, The Role of Public Procurement in Making Textiles Circular, 5, <https://www.pianoo.nl/sites/default/files/documents/documents/ecapworkwearreport-maart2017.pdf>.

³⁴ Supported by DPW Consult GmbH (2017), in personal correspondence.

³⁵ The following professional wear companies / organisations were interviewed (in alphabetical order): Albiro AG, CWS Boco Supply Chain Management GmbH, Lauffenmühle GmbH, European Textile Services Association (ETSA), Klopman, Utebel and Work Fashion.

Fibre	Currently available	Limitations
Recycled polyester	Most widely used fibre, with suppliers starting to offer some garments with recycled polyester. The quality is said to be the same, although more insight is needed as there is still a relatively low uptake in professional wear and, as a result, a lack of feedback.	The colour whiteness grade may not be as bright as for example the medical wear would expect it to be. For PPE, using recycled polyester in place of polyester could be possible in theory but it is hardly done as PPE wear is a combination of many different materials and largely constructed from chemicals (see Alliander example, p.25).
Recycled nylon	Still very small scale in the industry in general and hardly mentioned in professional wear.	The market is limited to a few suppliers, which makes the access to this fibre more expensive.
Recycled wool	Not widely referred to.	Although it is an old recycling method, the market is very small and still needs to be built up.
Recycled cotton	It depends on the applicability. The Dutch example in Chapter 4 shows that using recycled cotton for certain products is possible. The market and large companies are working to find solutions, but the journey is a long one.	Lower quality and performance can be an issue for professional wear. However, these challenges can be overcome if recycled cotton is mixed with virgin fibre.

Table 6: General overview of the market of professional wear with recycled fibres

2.3. Challenges identified for the public procurement of recycled fibres

Based on interviews with professional wear suppliers at various stage of the chain, solutions and technologies are rapidly developing in this area yet some professional wear sector-specific challenges still need to be looked at/overcome on the recycled fibres topic:

- ✓ Price: almost all interviewees mentioned this as a number one challenge. Professional wear is a price-conscious sector and as the price of recycled fibres is currently still higher than that of virgin fibres (by 10-20%), it is challenging to adopt recycled fibres. However, the sector can only evolve if there is a clear demand for recycled fibres from public procurers and the industry in general.
- ✓ The high product standards required by professional wear differ from those in the fashion industry. The fibres need to be of high quality, which could be problematic with certain recycled fibres. The market can however offer solutions or blends with virgin fibres.
- ✓ Recyclability: the challenge to recycling the garments is the issue of blends, the potential chemical residue from previous treatments and the challenge of dirtiness in professional wear. But as examples show, some companies have heavily invested in providing solutions for circularity (see Chapter 3 of this study).

The question is how the market can be supported in order to take on these challenges. Section 4.1 below discusses Dutch pilot projects with recycled fibres. These projects came to the same conclusion: the market needs further support.

2.4. Expected future developments in professional wear

Based on interviews with industry actors, the expected developments in the area of recycled fibres are unclear mainly due to the fact that the market is at a very early development phase. Nevertheless, some figures have emerged which give some initial insight: Utexbel mentions that the production of fabrics out of recycled fibres represents less than 5% of their business, but the company is aiming for 10% in the next five years³⁶. CWS Boco is expecting the market of recycled fibres to pick up in the next five years, to about 5% versus virgin fibres³⁷. Other interviewees also mention that the next five years will be key in seeing a development in the circular economy. Professional wear would clearly have a role to play if closed-loop recycling (textile to textile) becomes technologically and economically viable, because the sector usually uses high quality material, which can become valuable input material for new garments. Also, unlike the fashion industry, the professional wear sector has a better control over a garment's end of life, which makes planning for recycling easier provided recyclability has been taken into consideration at product development stage (see Section 1.5). Yet the journey to reach this is still very long.

3. Innovations in recycled fibres and recyclability

Today, many initiatives have emerged to find technologically and economically viable solutions for textile to textile recycling, but none are at industrial scale yet. The market is being pushed through the demand from big fashion brands that have committed to circularity such as H&M, C&A and Kering. 62 million tons of textiles are put on the market every year³⁸, but this waste is not yet becoming an input for recycled fibres. A few reasons for this and solutions being worked on are analysed below (please note that the list is not exhaustive):

³⁶ Interview Utexbel, August 2017.

³⁷ Interview CWS Boco, August 2017

³⁸ Global Fashion Agenda & The Boston Consulting Group, *The Pulse of the Fashion Industry* (2017), 8, http://globalfashionagenda.com/wp-content/uploads/2017/05/Pulse-of-the-Fashion-Industry_2017.pdf

Challenge 1: textile garments are often a blend of different fibres (polyester/cotton, cotton/wool, etc.), which makes recycling very challenging.

Solution 1: Chemical recycling to separate blends

Initiative	Description	Investments
Re:newcell	A Swedish company named Re:Newcell is working on a technology to retrieve the cotton or cellulosic fibre from post-consumer waste through a chemical process. The result is dried cellulose called a dissolving pulp, which can be used as basis to make viscose or lyocell products (annex 6)	The company is supported by Fouriertransform, the Swedish government-owned investment body which has invested 5 million euros in the company. They are building a production site in Sweden that will have a capacity of 7,000 tons per year, which equals 28 million t-shirts.
HKRITA and H&M³⁹	H&M entered into a four-year partnership with the Hong Kong Research Institute of Textiles and Apparel (HKRITA) to find solutions to recycle blended textiles into new yarns and fabrics. Through a hydrothermal (chemical) recycling process, they found a way to self-separate cotton and polyester blends and the polyester can be re-used directly without quality loss. The cotton turns into a cellulose powder but the application of this powder still needs to be defined.	The total investment in this project is 30 million euros for a four-year collaboration. A pilot plant is planned and will be operation in 6-12 months ⁴⁰ . The next phase will be to demonstrate the commercial viability of the technology, which if positive, will be licensed out to the market.
Worn again	Worn again works on the separation of polyester and cotton blends through a chemical process. It has managed to separate and recapture polyester and cotton, which can then be re-used as virgin-equivalent input in the supply chain.	No data about the investments but the future model will be to offer licenses to commercial recyclers once they are ready technologically for scaling up.

Table 7: Initiatives working on chemical recycling to separate blends and the investments made

Solution 2: Design for circularity

The goal of design for circularity is to take into account the end of life already in the design phase. A few companies have worked on solutions:

Name	Concept	Description
Schoeller AG / Wear2Wear Partnership	Design for circularity	<ul style="list-style-type: none"> - Offers a fabric made of 60% recycled polyester (with the goal of scaling up to 100%) including a technology that makes the fabric feel like a polyester/cotton blend. - At the end of its life, the garment can be recycled into a new garment through the Wear2Wear partnership (see Annex 7). - The fabric and garment meet strict waterproofing, breathability and comfort requirements. Water- and dirt-repelling technologies based on renewable raw materials ensure that the textiles are developed and manufactured entirely without the use of PFC. On the other hand, very specific performance attributes such as flame retardants cannot be included, as this would prevent the recyclability.

³⁹ H&M Group, *Technological Breakthrough: Successful Method Found for Recycling Blend Textiles into New Fibres* (2017), <https://about.hm.com/en/media/news/general-2017/Successful-method-found-for-recycling-blend-textiles-into-new-fibres.html>.

⁴⁰ Ecotextile News (October/November 2017), 28.

Dutch Awareness	Design for circularity	<ul style="list-style-type: none"> - Developed a fabric called Infinity, which can be mechanically recycled up to eight times before having to include virgin polyester in order to strengthen it. - Offers professional wear made out of 100% polyester and offers public procurers a take-back system of the garments. - Enabled through a circular track and trace system, which guarantees that the Infinity fabric is in the product. - Worked on several pilot projects with the Dutch government and has a lot of knowledge on circular procurement.
Lauffenmühle	Cradle to Cradle C2C	<ul style="list-style-type: none"> - In this case, Lauffenmühle developed biologically regenerative yarns, fabrics and ready to wear accessories meeting the stringent technical requirements of industrial laundry and having a high abrasion and pilling resistance. - C2C takes into account the garment's end of the working life: the biodegradable material can be taken to a commercial composter and turned into soil to be returned to the earth without leaving any traces of harmful substances (more information in annex 8).

Table 8: Example of companies offering solutions for easy recyclability of textile

Challenge 2: Mechanical shredding can make the fibre shorter and therefore the fibre loses quality.

Chemical recycling is a strong alternative, as it helps preserve the performance of the material.

Initiative	Description	Investments
Econyl from Aquafil	Nylon is more difficult to recycle, because, as mentioned earlier, it needs a large input of the same kind of nylon for it to be feasible. However, Aquafil, a leading company in the production of Nylon 6, has developed the Econyl Regeneration System, which produces Nylon 6 from nylon waste such as fishing nets and carpet fibres. The ECONYL® yarn can be regenerated infinitely without any loss in quality.	Invested 35 million euros to develop the Econyl Regenerative System and produces more than 20,000 tons of Econyl yarn per year.
Refibra™ from Lenzing	After four years of research and development, the Lenzing Group launched a new fibre, named Refibra™, which is a mix of pulp made of cotton scraps from post industrial waste (20%) and eucalyptus wood pulp (80%), resulting in a new TENCEL™ Lyocell fibre type. Refibra™ is the first cellulose fibre including recycled material that can be produced on a commercial scale and is applicable for professional wear, especially in markets already using TENCEL™ branded fibres. In the next couple of years, Lenzing will make this fibre available to public procurers via manufacturers, mainly as a blend between polyester and Refibra™. See more in annex 9.	The first partnership of Refibra™ with international companies could see up to 48 million garments produced from 3,000 tons of textile waste.

Table 9: Example of companies working on chemical recycling of fibres

Textile recycling today is like laying a jigsaw puzzle. All actors of the chain need to work together, step by step, to find solutions to technological challenges arising from each part of the supply chain. Only when it becomes economically and technologically available for all parties, will it take off.

4. Other countries' examples

This section discusses measures taken by other countries to procure professional wear with recycled fibres and to consider end of life solutions for professional wear.

4.1. The Netherlands: encouraging circular procurement nationally

Most notably, the Netherlands shows strong commitment to circular procurement. The country developed a government-wide circular economy programme named "A Circular Economy in the Netherlands by 2050". The first established objective is "a 50% reduction in the use of primary raw materials (minerals, fossil and metals) by 2030"⁴¹. In 2013, the Green Deal⁴² on Circular Procurement was launched and 45 public and private parties took part in the challenge to promote the circular economy through procurement policies⁴³. The aim was to build knowledge through pilots (80 in total) meant to be an initial phase before scaling up.

4.1.1. Dutch Ministry of Defence: procurement pilot on recycled fibres

The Dutch Ministry of Defence employs 58,800 people and is a big user of textile products in its military equipment. Under a national procurement plan for textiles and with the objective of exploring opportunities for closing the loop, the ministry organised two pilots, one on recycled fibres and one on the collection and sorting of discarded professional wear. Below, the process of procuring textiles with recycled fibres is discussed⁴⁴:

a. An initial market dialogue

In January 2014, the Dutch Ministry of Defence, with the support of Rijkswaterstaat (part of the Ministry of Infrastructure and the Environment), started a dialogue on the application of recycled fibres through a market consultation and a meeting with suppliers. The meeting gathered all suppliers working with the Ministry on the one hand and procurers and internal decision makers on the other in order to investigate how the market responds to the requirement of using recycled fibres. Suppliers were asked how much recycled content can be included in a garment (the question was specific to post-consumer textile waste, so excluding for instance recycled polyester from PET bottles). Answers ranged from 0 to 75%.

⁴¹ Government of the Netherlands, *A Circular Economy in the Netherlands by 2050* (2016), 5, <https://www.government.nl/documents/policy-notes/2016/09/14/a-circular-economy-in-the-netherlands-by-2050>.

⁴² Green Deals are voluntary agreements between a central government and other organisations, intended to stimulate sustainable innovations and remove potential barriers, such as restrictive legislation.

⁴³ "Green deal on circular procurement: a special partnership", *Magazine Green Deal Circular Procurement* (June 2017), 8, http://www.ecap.eu.com/wp-content/uploads/2017/07/ENG-Green-Deal_Circular-Procurement-Magazine.pdf.

⁴⁴ Information gathered through an interview with Rijkswaterstaat, Dutch Ministry of infrastructure and the Environment.

This initial discussion with different stakeholders in the supply chain was crucial to gaining insight into market possibilities and to getting the project off the ground.

b. Writing of the tender

This initial meeting formed the foundation for a call for tenders released in October 2015 by the Dutch Ministry of Defence for the on-demand sourcing of 53,000 green overalls, 10,000 washcloths and 100,000 towels with recycled content over a period of four years. The tender was very specific and one of the mandatory reward criteria was that the textile must contain at least 10% of recycled content from cellulose material (not coming from PET bottles). The higher the percentage of recycled fibres, the more points awarded (see Annex 10 for more details on the award criteria).

The contracts were awarded in June 2016 to two Belgian companies, which offered, for example, 36% of recycled cotton in the towels and 14% of recycled cotton in the overalls. A certification from an accredited institute was required to prove the percentage of recycled content in the textile, which is usually difficult to test. Microscopic testing can establish if recycled material is in the product. However, this does not establish whether this is pre- or post-consumer waste.

c. Lessons learnt⁴⁵

More time:

The market needs more time than the usual number of days given between publishing the contract and the actual closure to adapt to these new requirements. In addition, because it is an "unusual request", suppliers need to be kept informed on the invitation to tender so they have enough time to anticipate it.

More functional specifications:

The original Schedule of Requirements (SOR) had too many technical specifications. Suppliers' feedback showed that procurers must be very specific on quality functions in the specifications. A circular economy tender must be written in a more functional way to grant the market space for solutions⁴⁶. It needs to concentrate on what a product is to do and be less interested in materials and dimensions.

45 Dutch Ministry of Defence, *Workwear: Dutch Ministry of Defence* (June 2017), <https://www.pianoo.nl/sites/default/files/documents/documents/rebusfactsheet15-kledingdefensie-engels-juni2017.pdf>.

46 Workwear Dutch Ministry of Defence note.

Be more open with existing tariffs:

Tight budget ceilings limit development potential. As a result, the public authority must be willing to take a cost increase.

4.1.2. Dutch Ministry of Defence: recycling their professional wear

Historically, the Ministry of Defence had textiles incinerated when they reached their end of life. In an effort to promote circularity, the ministry explored the potential of recycling and reusing discarded textiles. As a result, an eight-year contract was signed with the BIGA Groep, a social company reintegrating people with a disadvantage in the job market, for the collection and sorting of 750,000 items per year of military uniforms and equipment. The items are divided into two groups: high-quality clothing is reused and end-of-life clothing is recycled and turned into new fibres. The objective is twofold: to keep these items in circulation and to encourage circularity⁴⁷. Other Dutch examples of procurement with end of life in mind can be found in Annex 11.

4.1.3. Alliander: a vision for circular safety wear

Alliander⁴⁸, a Dutch public infrastructure maintenance company for the electricity and gas grid, has an overall vision to be 40% circular by 2020. One of their ambitions under this vision is to develop a complete circular package for safety workwear and personal protection items. Based on the results of a complete market scan, this is currently non-existent, at least for the multi-norm workwear used by Alliander as its safety wear. As a way to help the company achieve this goal, in June 2017, Alliander published a European tender. In this procedure, Alliander identified that a fully circular package, including design, manufacturing, distribution, maintenance, high quality reuse and the required IT systems (including track & trace and a webshop) is only possible through intensive market cooperation and supply chain integration. In order to achieve this vision, the market needs time, momentum, understanding, commitment and basically a change in the business model. The contractual duration of the tender is specified as 15 years. The reason for doing so is that the investments to be made by the market and the entire supply chain would be disproportional if the “standard” tender law duration would have been required. The length of the project offers the opportunity to support the development phase: giving time and financial support to the market including a viable return on investment. The stakes are high because safety wear is made of complex materials, so it is not yet a product fit for recycling.

⁴⁷ Dutch Ministry of Defence, *Workwear: Dutch Ministry of Defence* (June 2017), <https://www.pianoo.nl/sites/default/files/documents/documents/rebusfactsheet15-kledingdefensie-engels-juni2017.pdf>.

⁴⁸ Company website: www.alliander.com

4.2. Nordic countries' push on textile recycling

Nordic countries appear to be leading the way on textile recycling in terms of innovations and initiatives taking place. Under the action plan for sustainable fashion and textiles, “Well Dressed in a Clean Environment”, launched by the Nordic Council of Ministers in 2015, knowledge and expertise is being promoted through different tools such as case studies of Nordic brands involved in recycled fibres and textile recyclability projects⁴⁹, an analysis of the challenges in the journey towards textile-to-textile recycling⁵⁰ and the organisation of a workshop to increase cooperation between different actors in the chain. In addition, many ground-breaking innovations on chemical recycling and material recognition take place in this region, making it a hub for research, expertise and implementation.

4.3. France: a system for end-of-life collection of professional wear

In April 2016, France signed its own first four Green Deals⁵¹, inspired by the Dutch model. One of these focuses on the collection and recycling of uniforms and professional wear. The initiative, named FRIVEP (*Filière de Réemploi / Recyclage Industrielle des Vêtements Professionnels: Reuse / Recycling of professional wear*), is supported by several entities from both the private and public sectors, such as the national rail company SNCF, the mail service La Poste, the City of Paris, the Ministry of the Armed Forces and the Interior Ministry, as well as several small and medium size companies⁵². In June 2017, all entities involved in the project carried out an inventory of their own professional wear assortment in order to establish the amount of textile, the main raw material/combination of raw materials used and the weight. The next phase is to look for a sorting centre that can collect professional wear to give it a second life. Since most of the professional wear in the case of the participating entities is owned by the employees, internal awareness raising campaigns have been launched for employees to return their professional wear when it reaches its end of life. This campaign will most probably be successful, as employees have already expressed concerns that textiles

⁴⁹ David Watson, Anja Charlotte Gylling, Tova Andersson, and Pirjo Heikkilä, *Textile-to-textile recycling: ten Nordic brands that are leading the way* (Copenhagen: Nordisk Ministerråd, 2017), http://norden.diva-portal.org/smash/record.jsf?dswid=3034&aq2=%5B%5B%5D%5D&af=%5B%5D&searchType=SIMPLE&sortOrder2=title_sort_asc&language=en&pid=diva2%3A1147645&aq=%5B%5B%5D%5D&sf=all&aqe=%5B%5D&sortOrder=author_sort_asc&onlyFullText=false&noOfRows=50&dspwid=3034.

⁵⁰ David Watson, Maria Elander, Anja Gylling, and Tova Andersson, *Stimulating Textile-to-Textile Recycling* (Copenhagen: Nordisk Ministerråd, 2017), http://norden.diva-portal.org/smash/record.jsf?dswid=-8842&aq2=%5B%5B%5D%5D&af=%5B%5D&searchType=SIMPLE&sortOrder2=title_sort_asc&language=en&pid=diva2%3A1161916&aq=%5B%5B%5D%5D&sf=all&aqe=%5B%5D&sortOrder=author_sort_asc&onlyFullText=false&noOfRows=50&dspwid=-8842.

⁵¹ The goal of the Green Deals is to encourage the adoption of innovative green solutions by supporting public-private partnerships working to lift the roadblocks towards a circular economy.

⁵² Press Release, April 2016, French Ministry of Economy and Industry: <http://proxy-pubminefi.diffusion.finances.gouv.fr/pub/document/18/20861.pdf>

are simply incinerated. The cost of collecting is split between the parties involved, with the objective that the initiative will eventually sustain.

5. Recommendations for Switzerland

5.1. Current examples in Switzerland

Recycled fibres and the end of life of professional wear are hardly addressed in the Swiss public procurement processes. This is partly due to a lack of awareness and overview of the current market solutions on the one hand and the fact that recycling may have an impact on normal procedures and can result in higher costs on the other.

However, some public entities are starting to explore the topic at hand, as outlined below:

- **Procurement of recycled fibres**

Both Swiss Post and SBB are sourcing items containing recycled fibres. Swiss Post already started in 2014 with the sourcing of shawls made out of recycled polyester. In early 2017, SBB issued a tender for high-visibility orange t-shirts and polo shirts complying with the norm EN 20471. The requirement for recycled polyester was not mandatory, but gave more points in the award criteria (more information available in Annex 12). The experience was positive: suppliers could fulfil the requirements and workers wearing the items did not feel any difference in comfort. The recycled content was verified through laboratory testing in Germany. In terms of price, SBB was willing to pay slightly more (up to 5%) for a recycled polyester offer, which encouraged the market to develop solutions.

- **End-of-life solutions**

Most of the professional wear in Switzerland ends up in incineration due to on the one hand a lack of awareness and solutions available and on the other hand for security reasons. Some public entities have however set out to find end-of-life solutions independently, mainly by giving professional wear to charities. For example, Swiss Post and SBB both work with the Swiss Red Cross, which ensures the further use of the items through either reselling or giving it to special initiatives. Through a formal contract with Textura, a recycler in Canton de Vaud, all services of the city of Lausanne can call a free number and have their professional wear collected by Textura. The recycler either sells the professional wear in its stores or ensures a safe downcycling of the products. The collaboration is price neutral and therefore attractive to both parties. Other initiatives are taking place but on a very small scale, as there is a lack of knowledge of this topic.

5.2. Recommendations for procuring professional wear with recycled fibres

"(Change) never happens with a 'big bang', it is almost always about taking many steps towards the goal"⁵³. As the Dutch example from the ministry of Defence shows, the market of recycled fibres needs to be encouraged and pushed by public authorities. Rather than understanding what the market can supply, the question should be: how can the market be built up? What kind of incentives does it need to make it work for all parties involved?

- **Create a space for dialogue**

Creating a space for dialogue between procurers and potential suppliers outside a formal tendering process is key. It would help public authorities have a better understanding of the market and know the requirements they can make in order to push the market to come up with innovative solutions. The circular procurement guide from MVO Nederland gives the following tips about what a public procurer could explore in such a dialogue⁵⁴:

- The amount of recycled content that can be included in the desired product that maintains the same quality/performance.
- The use of alternative fibres to allow recyclability.
- The opportunity for suppliers to lease the product so that they can include an end-of-life solution in the tender.
- Removable logos in order to increase end-of-life potential.
- The best fibre mix to encourage recyclability.

In Switzerland, public authorities engaged in Green Public Procurement such as Canton de Vaud and the City of Zürich have voiced strong interest in such a dialogue on recycled fibres and textile recyclability (amongst other sustainability topics). This dialogue could be anchored under the new platform Go for Impact⁵⁵, which would be ideal as it aims at exploring how the Swiss economy can use less resources while improving economic efficiency and creating social benefits. As a result, it would help public procurers and suppliers to align and explore ways of preserving resources through sourcing recycled fibres and through considering end-of-life solutions.

⁵³ Magazine Green Deal Procurement, June 2017, Bart Vos, page 6: http://www.ecap.eu.com/wp-content/uploads/2017/07/ENG-Green-Deal_Circular-Procurement-Magazine.pdf

⁵⁴ MVO Nederland, *Circular Procurement Guide*, <https://mvonederland.nl/circular-procurement-guide>.

⁵⁵ <https://www.gruenewirtschaft.admin.ch/grwi/en/home/go-for-impact/Go-for-Impact.html>.

- **Use the EU GPP Criteria on textiles and ECAP**

In June 2017, the European Commission published new voluntary EU Green Public Procurement (GPP) criteria for textile products and services⁵⁶. In this version, criteria on recycled content and end of life solutions have been included and are formulated in such a way that procurers can integrate them in tender documents with minimal editing (see relevant EU GPP criteria on recycled content and end of use summarised in Annex 13).

Another tool available to public procurers is the European Clothing Action Plan (ECAP), an initiative supported by the EU Life, which aims at reducing clothing waste across Europe and embed a circular economy approach. Public procurers can participate to help develop new criteria and share the knowledge and expertise of other public procurers in the industry⁵⁷.

- **Work with functional specifications rather than technical specifications**

In the current situation, Swiss procurers sourcing garments with recycled content work with award criteria assigning more weight to suppliers proposing products with recycled fibres. When it comes to procurement that considers specifically end of life, product functional specifications are more important than technical specifications. This allows the market to come up with more innovative solutions that they would not consider if the technical specifications were listed.

- **Verify the content**

As the examples above show, there are two ways to guarantee recycled content in a garment:

- a. Certifications

Two main standards on recycled content in textile and other applications are available on the market. The Global Recycled Standard (GRS) verifies the recycled content in the final product according to ISO norms. It reviews the social, environmental and chemical requirements at each processing stage. The Recycled Claim Standard (RDS) is similar, but focuses only on the recycled content in the product, not on how it was produced.

- b. Microscopic examination

This method can show the amount of recycled fibres, but it cannot ascertain whether pre- or post-consumer waste was used. The public procurer should therefore ask the supplier for further proof of transactions down the supply chain.

⁵⁶ http://ec.europa.eu/environment/gpp/pdf/criteria/textiles_2017.pdf

⁵⁷ ECAP project overview: <http://www.ecap.eu.com/wp-content/uploads/2015/10/Public-Procurement.pdf>

5.3. Recommendations for end-of-life solutions for professional wear

Today in Switzerland, the collection of old textiles and shoes from households is organised by organisations such as Texaid and its daughter entity Contex, Tell Tex or I:Collection. These organisations prolong the life of a garment, which is seen as the most environmentally friendly step, because no alteration to the products is needed. For example, the 36,000 tons of textiles collected by Texaid per year in Switzerland through bins, street collections and selected clothing stores are processed as follows:

- 65% of the garments are being resold as they are.
- 15% are downcycled into wipes.
- 15% are downcycled into shoddy wool and insulating materials.
- 5% are waste products⁵⁸.

Most of the time, professional wear does not enter this stream, because it cannot be resold as it is (image components like logos have to be removed, for example). Other public entities, such as Armasuisse, have to incinerate most of their uniforms for security reasons. Yet unlike the fashion industry, public procurers and public companies know exactly what material is in the product and when the item is due to reach its end of life, which could be a clear advantage for the recycling process. Indeed, not knowing the garment composition is a big challenge for recyclers. Different initiatives, for example the SIPtex Consortium in Sweden⁵⁹ or the Fibersort from Circle Economy in the Netherlands⁶⁰, are currently working on cutting edge identification systems that will help recognise the composition of a garment in an automated way which will in turn increase the efficiency and accuracy of sorting. This will lead to better business opportunities for recyclers, which is strongly needed for a valid textile-to-textile recycling business model.

Today, public procurers or public companies organise their own recycling by either incinerating their professional wear or by giving it to charity. Based on the example of the French initiative FRIVEP, it would be useful to review other end-of-life options than incineration for Switzerland. The recommendation would be to:

⁵⁸ Interview with Texaid, July 29, 2017.

⁵⁹ IVL, *New technology may revolutionize textile recycling* (2017), <http://www.ivl.se/english/startpage/top-menu/pressroom/press-releases/press-releases---arkiv/2017-03-28-new-technology-may-revolutionize-textile-recycling.html>.

⁶⁰ "The Fibersort is a technology that automatically sorts large volumes of mixed post consumer textiles by fiber type. Once sorted, these materials become reliable, consistent input materials for high value textile to textile recyclers". Circle Economy website: <https://www.circle-economy.com/case/fibersort/#.WjKC10tG0UE>

- Investigate the amount of professional wear that would not need to be incinerated if solutions would be in place.
- Review the reasons behind the current lack of infrastructure for the collection of professional wear: are there any legal barriers that need to be overcome?
- Review the existing options on the market and the opportunities for collaboration.
- Review the levers that would make recycling economically viable and define the potential for financing.

Due to the size of Switzerland and the amount of professional wear procured, it would make more sense to build a system using existing recycling facilities. However, expectations should be managed: until textile-to-textile recycling technologies are more advanced, professional wear would be resold or downcycled to make insulation or input for other industries. For now, the motivation for setting up a recycling system for professional wear would be to divert waste from incineration rather than to provide input material for textile-to-textile recycling. If textile-to-textile recycling is the ambition, another few years are needed.

Concluding remarks

The current market for recycled textiles and textile recyclability is buoying and announcements on key recycling innovations are released on an almost monthly basis, which makes it challenging to keep up to date. Yet innovations still have to prove their technological and economic viability in order to secure uptake by the industry. Indeed, price remains a significant barrier for the different actors in the chain, as could be the quality and performance. The sector needs more hindsight, especially for the application in professional wear. Based on the different interviews and reports, it is estimated that the coming five years will be crucial in making the business case for textile recycling, especially when it comes to retaining the quality of the fibres in the recycling process and addressing recycling of blends in textile. Recycling technologies need to be further developed and reach industrial scale but this means that bridging the gap and starting a dialogue between the different actors in the market is key. Public procurers cannot get a good grasp of whether the market can offer recycled fibres in the different textile applications they need and the market will only invest in innovations if there is a clear requirement for recycled fibres in the tenders. This could be resolved through the setting-up of a platform that would facilitate these dialogues and at the same time keep up to date on this important and high potential discussion.

On the end-of-life aspect, Swiss public procurers are not aware of end of life solutions for their professional wear. Some have taken the lead and implemented their own solutions, mainly through charities and recyclers. This is a good strategy for diverting this waste from incineration and preventing it from being disposed of in an uncontrolled way. But since the demand of good quality garments for a textile-to-textile recycling is not yet happening, professional wear recycling is not attractive for recyclers through their usual recycling channels. Consequently, more research needs to be done to really define a vision on recycling of professional wear for Switzerland and explore options, their advantage and their viability.

ANNEXES

The annexes below are meant to give additional information about aspects addressed in the main report.

Annex 1

Much of the information shared by companies is sensitive and therefore details of names and numbers cannot be attributed to individual companies or persons interviewed. The researcher would like to warmly thank individuals from the following companies/institutions for having taken the time to provide input for this study (in alphabetical order):

Albiro AG, Alliander (Netherlands), Aquafil, CWS Boco Supply Chain Management GmbH, Canton de Vaud, City of Lausanne, City of Zürich, Coord 21, Dibella, Die Post, DPW Consult, Dutch Awareness, European Textile Services Association (ETSA), Fashion for Good, FRIVEP (France), Hälg Textil AG, I:Collect, Lauffenmühle GmbH, Lenzing AG, Klopman, Mistra Future Fashion, Re:newcell, Rijkswaterstaat (Dutch Ministry of Infrastructure and Water Management), SBB, Schoeller AG, Sustainability in Fashion, The Swedish National Agency for Public Procurement, Texaid, Textile Exchange, Unifi, Utexbel, Work Fashion and WRAP UK.

Annex 2

The industry's linear model is an obvious stress on natural resources as shown in the graph below⁶¹. In 2030, water consumption is projected to increase by 50%, energy emissions by 63% and waste creation by 62%, compared to 2015:

⁶¹ Global Fashion Agenda & The Boston Consulting Group, *The Pulse of the Fashion Industry* (2017), 10, http://globalfashionagenda.com/wp-content/uploads/2017/05/Pulse-of-the-Fashion-Industry_2017.pdf.

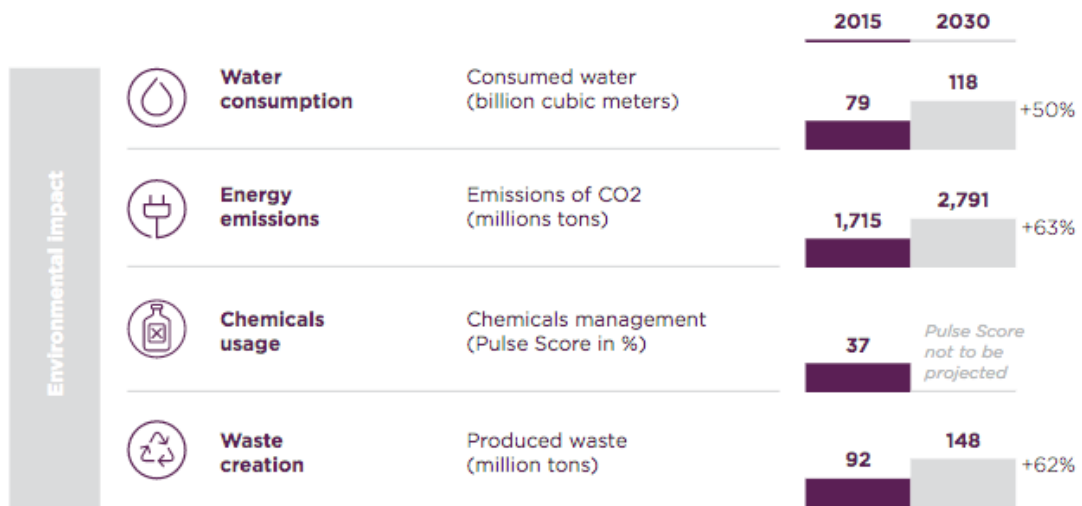


Figure 4: Projected increase of environmental impacts based on the increase of global fashion consumption

Annex 3

The graph below illustrates the way in which technological and biological nutrient-based products and materials circle through the economic system⁶². It is named the butterfly model and sets to visually explain the circular economy concept:

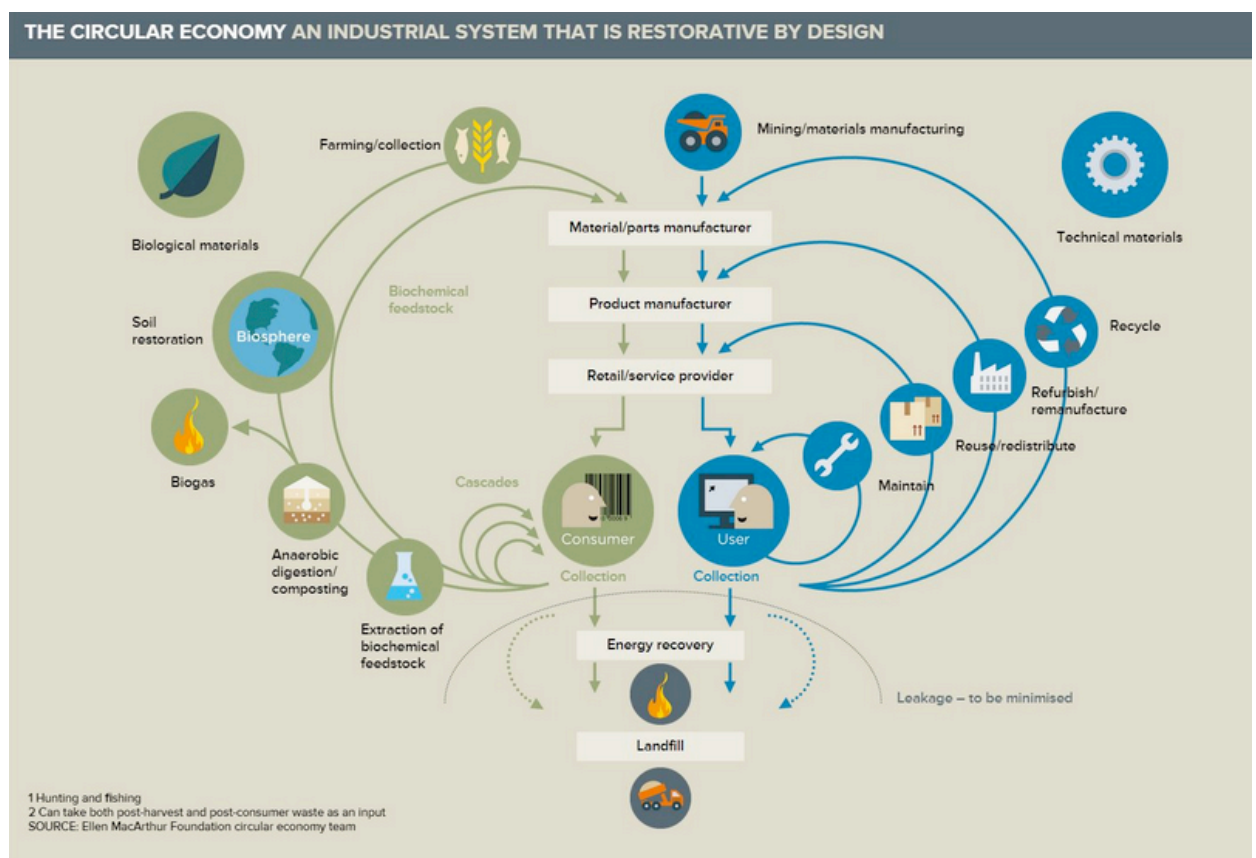


Figure 5: The butterfly model or the visual representation of the circular economy concept

⁶² Ellen MacArthur Foundation, *Circular Economy System Diagram*, <https://www.ellenmacarthurfoundation.org/circular-economy/interactive-diagram>.

Annex 4

- This movie about recycled polyester from National Geographic, published in December 2009, explains the mechanical recycling of PET bottles:
<https://www.youtube.com/watch?v=zyF9Mxlcltw>.
- Below is an overview of both mechanically and chemically recycled polyester. Chemical recycling includes an additional chemical step compared to mechanical recycling (shown as an add-on text box below)⁶³:



Figure 6: Visual representation of the process to make recycled polyester fiber from PET bottles

In chemical recycling, the material is first depolymerised to the base-chemical molecule called monomer and then re-polymerised with the help of chemical additives (typically methanolysis, glycolysis, or hydrolysis) before being extruded into chips.

⁶³ https://www.trustedclothes.com/blog/wp-content/uploads/2016/04/recycledpolyester_01.jpg

Annex 5

Below image is an overview of fabric composition of key garments in corporate wear⁶⁴:

Clothing type	Garment	Purpose	Composition	Branding
PPE	High visibility jacket	The principal function of this garment is to ensure the worker is clearly seen in all light conditions, generally neon yellow or orange with reflective strips applied to catch light in darkness.	100% polyester, typically PU coated	Embroidered, badge applied by heat seal or stitching
PPE	Overall / boiler suit	Often looking like a regular boiler suit, fabrics can be treated to be flame retardant. Where branding is required, this should receive the same treatment as main body of garment.	65/35% polycotton	Made in corporate colours, or badge applied
Uniform	Military dress	Formal dress uniforms that, depending on the role of the wearer, can be worn on a daily basis or only for occasions. The colour of the garment will often remove the need for branding.	Can vary: 50/50% wool/poly; 100% wool	Not typically branded
Career-wear	Man's or lady's suit	For a man this would be a jacket and trouser, for women this can be jacket with dress, skirt or trouser, all made in the chosen corporate colour, often in a variety of style options. Developments in garment technology would mean that most suits are washable.	Can vary: 100% poly; 50/50% wool/poly; 65/35% poly/viscose	Tax tabs
Career-wear	Blouse	Often used to inject strong and bright corporate colours, patterns and logos into the careerwear ranges. Generally designed and developed to be very low maintenance.	Varies for purpose often cotton rich blends – with polyester, sometimes elastane	In the fabric
Career-wear	Shirt	Tend to conform with conventional men's shirt styling.	Often cotton rich blends – with polyester or sometimes elastane	Can have tab to fasten name badge
Work wear	Polo shirt	Straightforward polo shirt, an easycare item that is smart but casual, and easily worn by either sex.	Can vary: 65/35% poly/cot; 100% poly	Corporate colour, embroidered branding
Work wear	Tunic or coverall	A garment that can be used as a uniform item, also worn over the workers clothes.	Can vary: 65/35% poly/cot; 100% poly	Corporate colour, embroidered branding
Work wear	Trouser	Generally a standard styled trouser that does not normally carry branding.	Can vary: 65/35% poly/cot; 100% poly	Generally not used
Footwear	Steel toe cap boots	Provided to many different job sectors for workers in manual roles	Mixed materials	n/a
Footwear	Non-slip shoes	Supplied to workers within hospital and kitchen type environments to avoid unnecessary falls	Mixed materials, typically rubber sole, with leather, textile and/or plastic uppers	n/a

Figure 7: overview of fabric composition of key garments in corporate wear

⁶⁴ WRAP UK, *A review of corporate workwear arisings and opportunities* (2012), 19.

Annex 6

Re:newcell

Founded in 2012, Re:newcell is a Swedish company that recycles garments using a chemical process. The process, initially developed by the Royal Institute of Technology in Stockholm, is as follows: they collect pre- and post-consumer textiles made out of cotton or cellulosic fibres from textile collecting and sorting companies, retailers and textile manufacturers. They then chop it to equal size, de-dye and de-finish the textiles and dissolve the material to molecular level. At this level, they separate the cellulose from other materials such as polyester and then dry the cellulose. The dried cellulose is called dissolving pulp, of which viscose and lyocell products can be made. The company is supported by Fouriertransform, the Swedish government-owned investment company, which has invested 5 million euros in the company⁶⁵. They are building a production site in Sweden that will have a capacity of 7,000 tons per year, which equals 28 million t-shirts.

"Re:newcell's technology has the potential to become a commercial and scalable solution for the industry and accelerate the journey from a linear fashion industry towards a circular one", says Cecilia Brännsten, Acting Environmental Sustainability Manager and circular economy lead at H&M group.

Annex 7

Wear2wear

Wear2wear is an innovative industrial partnership dedicated to bringing solutions for closing the textile loop. Five European companies, each representing a phase of the recycling process, collaborate in order to develop cutting-edge production systems that will turn textile fibres from used clothing into new functional fabrics (textile to textile). The five companies are:

Fabric supplier	Outer material and linings	Recycler	Upcycler	Project initiator
Schoeller Textile AG	Sympatex AG	Glaeser	Märkischer Faser	Dutch Spirit
Develops the sustainable and high-tech Inspire fabric with maximum clothing comfort.	Provides a 100% recyclable, PTFE- and PFC-free membrane as well as recycled outer materials and	Takes the garment made of the Inspire fabric back and prepares it for the recycling process (removing	Makes new polyester yarn out of the inspire fabric through an upcycling process.	Brainchild for the wear2wear concept, Dutch Spirit's mission is to increase the awareness of sustainable clothing and

⁶⁵ Press release: <http://www.fouriertransform.se/Global/pdf/Pressrelease-Renewcell-160923-eng.pdf>

	linings.	zippers, buttons, etc.)		provide circular clothing in the corporate and workwear segment.
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Table 10: Wear2Wear partnership explained

Wear2Wear started in 2016, so the partnership is still in its infancy, but it offers a promising solution for recyclability. The challenge will be to have enough Inspire fabric on the market to be able to collect it in order to make new Inspire products out of it. This is where the professional wear sector is key, because the end of life is mostly planned and provides a defined and significant input of material in order to create a new recycled yarn out of it.

Annex 8

Lauffenmühle

In an attempt to break away from professional wear being seen as disposable, Lauffenmühle successfully developed products in line with the Cradle to Cradle principle. The idea was to explore the possibilities to return such clothing to the biological cycle at the end of its working life. Overall, the project incorporated the development of yarns, fabrics and ready-to-wear accessories, all of which needed to be biologically regenerative while meeting the stringent technical requirements of industrial laundry and have a high abrasion and pilling resistance. Following the stringent C2C requirements, all processes have been designed and developed from spinning (yarn called infinito® which is a biodegradable polymer derived from oil blended with Tencel®) to weaving, finishing and to fabrics called reworx® fabrics.

The most challenging for garment makers working with fabrics from Lauffenmühle was the lack of suitable C2C accessories (sewing yarns, cords, elastic straps, labels, zippers, buttons). The company therefore developed a range of own accessories certified C2C.

Lauffenmühle sees this Cradle to Cradle registration and certification as the "Supreme Discipline Of Circular Economy" as there is no loss of material throughout the loop. It also gives public procurers full transparency on the professional wear supply chain from fiber to garment. Cradle to Cradle takes into account the garment's end of the working life: the biodegradable material can be taken to a commercial composter and turned into soil to be returned to the earth without leaving any traces of harmful substances. The company continues working on the topic and is looking to find solutions to obtain biogas out of the compost.

Refibra™ from Lenzing

Lenzing is an Austrian company whose main business is to develop and commercialise high quality, botanic cellulose fibres, mainly made from wood. These include TENCEL® (lyocell), Lenzing Modal®, Lenzing Viscose®, which are their main brands. A world leader in this area, Lenzing is very much invested in sustainability. Early in 2017, Lenzing launched its Refibra™ fibre, which it sees as its initiative to drive circular economy in the textile world.



Figure 8: Visual representation of the Refibra™ process

Cotton scraps represent approximately 20% of the pulp that is used in the final fibre composition and it is made of post-industrial but pre-consumer cotton scraps. The success of this fibre relies on having access to an ongoing supply of waste materials from reliable sources, which Lenzing secured through a collaboration with a big international brand. The remaining 80% is actually eucalyptus wood pulp, the same process as used for TENCEL™ lyocell fibres. This is why this new fibre is called the Reborn TENCEL™ fibre. In order to assure the customers that the fibre, made from recycled material, is really in the textiles,

Lenzing has developed a new identification system, which helps to identify Refibra™ in the finished textile⁶⁶. The quality level is said to be the same as that of virgin TENCEL™.

Annex 10

Dutch Ministry of Defence Award criteria for their pilot on recycled content in overalls and other products:

The tender is awarded as follows:

- 40 points for the most economically advantageous offer
- 20 points for the highest percentage of recycled content from cellulose material
- 20 points for the confirmation of the amount of recycled fibres
- 10 points for the Data sheets with quality and material requirements

Regarding the content, the points are calculated as follows (based on the percentage of recycled content in the final product):

≥50% - 20 points

30% - 10 points

10% - 0 points

Ten percent of recycled content is the minimum requirement. The intermediate steps are calculable by 0.5 point increments. Everything above 50% content does not add extra points.

The price is related to the amount of recycled fibre content. If a tenderer is more expensive due to a higher content of recycled fibres, the score is calculated accordingly by adding a multiplication on the price score. For 10% content = factor 1.0, 20% content = factor 1.2, 50 content = factor 1.8.

If microscopic examination shows that the indicated amount of recycled fibres is observed, the full 20 points are allocated. Higher amounts do not add extra points.

⁶⁶ Lenzing, *Refibra™ fiber – Lenzing's initiative to drive circular economy in the textile world* (2017), <https://www.lenzing.com/en/press/press-releases/detail/article/2017/1/07/refibraTM-lenzings-beitrag-zur-kreislaufwirtschaft-in-der-textilwelt.html>.

Annex 11

Under the series of pilots on circular procurement organised in the Netherlands, other projects were initiated:

Public entity	Project
Rijkswaterstaat (Ministry of Infrastructure and the Environment)	<p>Leasing temporary professional wear to be recycled:</p> <ul style="list-style-type: none"> . Lock stewards work seasonally in the summer to supervise the waterways. . 50 lock stewards were issued caps, polo-shirts, raincoats and fleece jackets (100% recyclable polyester) supplied by Dutch Awearness. . Overall good performance and the items could be recycled to the same items the next year. . Only the raincoats had to be mixed with virgin material to have the strength required for a new item.
Dura Vermeer (Construction and Infrastructure)	<p>Circular professional wear:</p> <p>The project, started in 2014, was a pilot to engage discussions with the markets on the possibilities for circular workwear. The project focused initially on safety vests. In 2015, Dura Vermeer gave three market parties the contract to develop a softshell parka and waterproof trousers containing material up to 85% reusable. The safety vest proved to be a difficult project to start with due to high safety requirements and the fact that the market is still in an early stage.</p>

Annex 12

Regarding the SBB tender, the following items and material composition were asked:

Type	Material Composition
T-shirt	60% Tencel / 40% PET
T-shirt	100% Polyester
Polo-shirt	60% Tencel / 40% PET

The requirement for recycled polyester was not mandatory but awarded more points in the award criteria, which were divided into price (70%), comfort (10%), recycled content (10%) and environmental certification (10%).

The SBB tender award criteria, weighing and awarding of the different criteria are as follows (not translated).

Zuschlagskriterien				
ZK	Zuschlagskriterien	Nachweis	Gewichtung	Max. Punkte
1	Preis	Ausgefülltes Preisblatt	70%	350
2	Tragekomfort	Schriftliche Bestätigung	10%	50
	T-Shirt/Poloshirt hat geruchshemende Ausrüstung + schnellere Rücktrocknungszeit			
3	Ökologische Nachhaltigkeit	Schriftliche Bestätigung des Garnherstellers	10%	50
	Das Gestrick aus 40 bzw. 100% recyceltem PET			
4	Ökologische Nachhaltigkeit	Zertifikat/Bestätigung	10%	50
	Der Stricker ist nach dem Bluesign- oder STEP-Standard zertifiziert			
TOTAL			100%	500

2. Tragekomfort (Gewichtung 10%)		
Note	Grössenpalette	Punkte für Zuschlagskriterien
1	Keine geruchshemende Ausrüstung oder kürzere Rücktrocknungszeit	0
3	Keine geruchshemende Ausrüstung, jedoch kürzere Rücktrocknungszeit	25
5	Geruchshemende Ausrüstung + kürzere Rücktrocknungszeit	50

3. Gestrick besteht aus PET (Gewichtung 10%)		
Note	Grössenpalette	Punkte für Zuschlagskriterien
1	Standard gemäss Pflichtenheft aus 40% bzw. 100% Polyester	0
5	Recyceltes PET an Stelle von Polyester verwendet	50

4. Strickerei nach STEP- oder Bluesign zertifiziert (Gewichtung 10%)		
Note	Grössenpalette	Punkte für Zuschlagskriterien
1	Strickerei ist nicht zertifiziert	0
3	Strickerei ist nach ISO 14001 zertifiziert	25
5	Strickerei ist nach STEP oder Bluesign zertifiziert	50

Figure 9: SBB tender award criteria for recycled polos and tee-shirts

Annex 13

Below is a selection of the relevant GPP criteria for recycled fibres and end of life solutions (these were taken as is from the EU Green Public Procurement Criteria for textile products and services).⁶⁷

Core Criteria	Comprehensive Criteria
Subject Matter	
The purchase of textile products with a reduced environmental impact	
Technical Specifications	
	<p>TS4. Polyester recycled Content Polyester fibre product(s) to be used in fulfilment of the contract must be manufactured using a minimum recycled content of 20%</p> <p><i>Note: Technical issues may be encountered in meeting other quality specifications required in a contract. This should be taken into account when evaluating tenders and could also be addressed through market enquiries or during competitive dialogue (if used).</i></p>
Award criteria	
	<p>AC2. Polyester and polyamide (nylon) recycled content Points will be awarded for polyester and/or nylon fibre product(s) to be used in fulfilment of the contract for each additional increment of 10 % greater than a minimum recycled content of 20 % pre-consumer and/or post-consumer waste.</p> <p><i>Note: Technical issues may be encountered in meeting other quality specifications required in a contract. This should be taken into account when evaluating tenders and could also be addressed through market enquiries or during competitive dialogue (if used).</i></p>
	<p>AC3. Polyester recycling Points will be awarded to tenderers that can demonstrate:</p> <ul style="list-style-type: none"> - that the design of the final textile product facilitates ease of separation for polyester fabrics at the end of a product’s service life; - the provision of a voluntary take-back route for the textile product so that the contracting authority can return polyester fabrics to be recycled or reused.

⁶⁷ European Commission, *EU Green Public Procurement Criteria for textile products and services*, http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm.

Durability and lifespan extension	
Technical specifications	
<p>TS8. Availability of parts and accessories <i>(Same for core and comprehensive criteria)</i> The successful tenderer must make spares available of all parts and accessories (e.g. zips, buttons, fasteners) that form part of the products to be supplied for a minimum of two years after product delivery <i>or</i> the duration of the supply contract (whichever is the longest). An indicative price list for these parts and accessories must also be provided.</p>	
Design for re-use and recycling	
Award criteria	
<p>AC5. Design for reuse and recycling <i>(Same for core and comprehensive criteria)</i> Garments must be designed so that any logos or distinctive identification features can be easily removed or overprinted without damaging the</p>	
Core Criteria	
Comprehensive criteria	
Maintenance	
Technical specifications	
<p>TS2. Maintenance of the textile assets <i>(Same for core and comprehensive criteria)</i> <i>This could also be combined with or formulated as an award criterion rewarding the most ambitious maintenance approach.</i> The tenderer of textile services, as part of their asset management plan, will extend the useful life of workwear and interior textiles by providing ongoing maintenance and repair services. This will, as a minimum, include <i>(as relevant to the textiles to be provided)</i>:</p> <ul style="list-style-type: none"> - provision of basic repairs, including repairing seam splits and stitching, the replacement of broken/lost parts and the fixing/replacement of zips and fastenings; - fabric panel replacement for workwear; - the retreating and proofing of functional coatings. 	
Take Back	
Technical specification	
	<p>TS3. Take-back system <i>This could also be combined with or formulated as an award criterion rewarding the most ambitious take-back approach.</i> The tenderer as part of their asset management system must operate a take-back system, or have formal arrangements with a take-back scheme, for the textiles supplied for use within the contract, to include the following elements:</p> <ul style="list-style-type: none"> · _collection systems installed in the contracting authority's own premises to facilitate <i>(where appropriate)</i> the sorting and classification of textiles; · _training and guidance material to ensure that staff of the public authority have a clear understanding of how to use the system; · _post-collection sorting activities in order to maximise the value obtained from reuse or recycling. This will, at a minimum, include segregation based on fibre, colour and condition of garment.
Contract Performance Clause	

	<p>CPC2. Take-back system</p> <p>The tenderer must report on the performance of their take-back system in accordance with the following requirements:</p> <ul style="list-style-type: none"> · _Surveys will be carried out of staff at the contracting authority’s facilities to determine how easy it has been to use the collection/segregation systems. These will be carried out within the first six months of the services and the findings used to identify/implement potential improvement measures. · _The proportion by weight of the collected textiles that have been reused or recycled and the associated value/kg of textiles obtained from the destination end markets to which they are sent will be determined and recorded on an annual basis. <p>The tenderer will provide a short summary of the staff survey findings and the potential improvement measures identified. An annual report providing a breakdown of the destination of the textiles and the value obtained from each end market will be provided.</p>
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Table 11: Relevant GPP criteria for recycled fibres and end of life solutions