SCIRT Objectives, setbacks and results 2024

SCIRT had the ambition to demonstrate the industrial production of new garments with a highest possible recycled content (from post-consumer textile waste), respecting the required characteristics for brands to include these in their regular collections. So of course, having these garments in the brands' stores in Fall 2024, is a key outcome!

Moreover, the research conducted throughout the project has led to exciting findings. We have developed a method to accurately determine the elastane content of a fabric, as well as the consecutive removal thereof. This can have an important impact towards facilitating recycling of textiles containing elastane. Before going to recycling, textile waste needs to go through accurate sorting: recycling processes have very specific input requirements in order to produce high quality secondary materials. 'Rubbish in, rubbish out' is a valid statement when it comes to textile recycling. So the sorting step was another key aspect of research SCIRT focused on. Automated sorting, at high speed and with high accuracy, and automatic dismantling (separation of parts that contain) zippers, buttons, labels, …) have been developed and implemented as Fibersort 2.0 and Trimclean.

Closing the Loop

SCIRT was set up as an actual production chain. The process involved step-by-step garment production, integrating new and innovative technologies. This included additional steps and actions necessary to produce high-quality recycled yarns, which were then used in the redesigned garments. This required developing new technologies (such as the development of the Fibersort and Trimclean), improving existing practices to achieve higher quality of recycled fibres at the pilot scale, and scaling up these practices for industrial production. Connecting all these dots obviously created interdependencies: a small issue or delay in one step has a significant impact on the timing of the successive actions. We also experienced this in our project, requiring a lot of back-and-forth to optimize processes, delaying production and requiring a great deal of flexibility across the production process. A clear challenge to comply with promises made and timelines defined, but also inspiring since this really strengthened the understanding of the involved value chain partners towards the importance of collaboration beyond the company borders. A crucial point in the transition towards a more circular system.

Key challenge of SCIRT: Yarn quality

One of the main challenges we started with was the quality of recycled yarns not aligning with the requirements from fashion brands. We wanted to make this one of our key objectives: making sure we increase the quality of recycled yarns and of the fabrics made with it, through alterations to current practices and implementation of new technologies. What has been crucial for this, was the improved sorting and dismantling of textile waste before going to recycling. The purity of the feedstock has proven to be crucial in order to increase the properties of the yarn after spinning. The approach to start with process alterations and optimization on a pilot scale, to be later upscaled to the industrial processes has proven to be very effective. Additionally, in the feedback loops to upstream steps in the production, like the sorting requirements and dismantling, but also towards the design of garments: improving design of clothing towards the future, taking into account the lessons learned through our recycling trials, can make a big difference towards quality and recyclability of clothing.

The quality of the recycled yarn is directly impacted by the length of the fibre resulting from the dismantling stage. With this in mind, the ESTIA engineering school and the CETIA technology platform were tasked with developing a semi-automated dismantling machine focusing on cutting precision. By combining laser technology with image processing and AI tools, the solution is capable of releasing only the hard points, thus preserving the integrity of the original fabric. The numerous experiments carried out on the cell have made it possible to establish a database highlighting the relationships between laser parameters (speed, power, focal length, etc.) and textile characteristics (thickness, colour, material composition, etc.). This solution, currently at the proof-of-concept step, needs to be scaled up to validate its effectiveness under industrial production rate constraints.

Insights gained about consumer perspective

In the SCIRT project, a better understanding of fashion consumers' choices and views was a target and to achieve this, workshops were therefore conducted. Finding indicated that while eager to contribute to sustainability, many have concerns about the quality and affordability of recycled textiles. Financial incentives, such as discounts for future purchases, significantly motivate consumers to dispose of old clothes responsibly, by donating or bringing to a reputable retailer that collects clothes for recycling. Despite budget constraints often leading to second-hand clothing purchases, environmental concerns remain a priority for more eco-conscious consumers. However, the issue of greenwashing undermines trust, emphasizing the need for increased transparency in sustainable fashion claims. Overall, consumers show a strong interest in sustainable fashion but need clear labeling and effective incentives to feel confident in their choices.

To improve the circularity of the textiles industry, addressing consumer needs must start at the EU level with policy frameworks, such as setting eco-design requirements to improve the overall quality of what is produced and marketed, including the (mandatory) use of recycled content, introducing harmonized eco-modulated extended producer responsibility (EPR) to improve the proper collection and end-of-life treatment of discarded clothing, and a Digital Product Passport to improve and ensure transparency. SCIRT has been working on producing a set of guidelines and recommendations on key policy interventions to make changes towards enabling consumers to confidently embrace sustainable and circular fashion practices.

Fibersort & Trimclean

SCIRT partner Valvan's most innovative solution related to the first crucial step in textile recycling, was the development of the Fibersort 2.0 during the SCIRT project. This technology automatically sorts large volumes of waste textiles by fibre composition (cotton, wool, acrylic, polyester and all possible blends) and colour by using near infrared (NIR) spectroscopy. A robot picker, also developed within the SCIRT project, takes clothing items from a pile and puts them piece by piece on a conveyor belt. This allows the Fibersort to run continuously, lowering the operational costs of the sorting process. Through SCIRT, the speed and accuracy of the Fibersort have been improved and gone from a 5/6 TRL to a level 9 TRL, enabling the sorting for textile-to-textile recycling at large scale. It further increases the marketable feedstock of textiles by 90%. The improved Fibersort technology has been developed in combination with a newly developed dismantling technology, the Trimclean. The Trimclean is an automatic dismantling machine that detects any impurities or so-called contamination of the feedstock, such as zippers, buttons, labels, … and separates these from the pure materials. Both Fibersort and Trimclean enable high-quality recycling of waste textiles as they produce a well-defined and pure feedstock at lower costs. Valvan, already a main supplier of machinery to automate the textile sorting process in the market with customers all over the world running sorting installations, is now commercialising both the Fibersort and Trimclean machine to its new and existing customers. Protection is currently in progress to avoid replication by other organizations. Valvan has an ongoing patent

application for the Fibersort and Trimclean that have double sided identification technology, which no current competitors are using.

SCIRT demos

As part of SCIRT, clothing brands Xandres, Bel & Bo, HNST and Petit Bateau created prototype garments and a small-scale collection, made with at least 50% recycled textile fibres. Xandres, Bel&Bo and HNST will exploit these collections in store. of which the first collections will be launched in Fall 2025. The demos follow as many circular design principles as possible, based on the limitations they experienced in the trials for making the prototypes.

At this time, the brands will only sell the limited pieces in their stores. Given the difficulties and roadblocks encountered for their ambitious objectives, they plan to continue with research and development in the closed loop value chain to strengthen the possibility of producing a garment. Meanwhile, Decathlon currently sells the Kamyla 500 woman's performance swimsuit made of their *NEGOMBO* recyclable and recycled material (not specifically textiles) in stores and online. The one-piece swim garment has no elastane in it, making it more easily recycled and prepared to enter the closed loop value chain after it has endured the 500+ hours of chlorine (compared to 100 and 200 hours for their other suits). Customer satisfaction responses have additionally indicated it being more comfortable due to the thicker fabric made to compensate for the missing elastane.

The *NEGOMBO* recyclable and recycled material-made swimsuit that Decathlon sells is made in 2 colors. The material of the swimsuit is patented to protect the technology. While the garment is not made out of recycled clothing, it is made to be recycled and is a technology that is protected and owned by Decathlon. In SCIRT, the *TANGALLE* was produced with an adjusted composition of the *NEGOMBO*, making the fabric lighter and different knit, making it stretchier and is planned to be commercialized for 2026.

Xandres had originally planned to recycle pants from their own brand and use the feedstock to make new pants, though the textile composition of this type of garment (consisting of polyester, wool and elastane) limited the possibility of recycling. The high quality of textile (high tension of the yarn) of the pants made it very difficult to recycle as well and costly from an energy and monetary perspective, though they were able to make a limited-edition two-piece in a stylish pied-de-poule fabric composed of 17% recycled wool from second-hand clothing, 36% recycled polyester, 25% new polyester and 22% new wool. The garments are available online and in stores and more information can be found here.

In addition to establishing a takeback program called Bel & Back through SCIRT, Bel & Bo will sell their 200 total pieces in store and continue to work to make garments in a circular value chain. The brand cannot replicate the garments due to high costs and their suppliers not being based in Europe. In the coming years, Bel& Bo will try to find a way to use the yarn produced during SCIRT that is made from recycled content in other products.

HNST will sell their limited demo garments to retail partners based on customer demand. They will further gather customer feedback and if the responses are positive on the fabric, the brand plans to incorporate the recycled textile to make more styles from recycled clothing.

The 5th brand, Petit Bateau will not exploit their demo garment due to difficulties in incorporating post-consumer recycled fibres in the baby bodysuit, which is of very high quality and made to be durable, however they will distribute the 200 T-shirts (2 styles of 100 T-shirts each) to their brand ambassadors to collect user feedback. Petit Bateau will exploit the ability to spin a yarn in NM 40/1 with 50% of frayed cotton fibres (originating from post-consumer garments). The brand will continue to work on dyeing frayed fibers in black and mix them with virgin cotton to produce a

uniform gray, as requested from their marketing team. Petit Bateau's ambition is to refine and exploit this technique which has already produced 20 t-shirt prototypes made for test wearing.

Elastane separation

After the successful work in developing a quick, easy and reliable detection method for **elastane**, SCIRT partners were also able to define and prove a method to remove elastane using non-hazardous solvent, while keeping other polymers (such as PET, PA66) intact. Furthermore, a feasible chemo-enzymatic recycling process of wool/polyethylene terephthalate (PET)/elastane blends to recover pure PET was successfully demonstrated. Besides this research, SCIRT partners also focused further on the search for an elastane alternative, using thermomechanical processes.

Bio-Upcycling

Researchers at BOKU, a research institute worked on bio-upcycling of viscose/polyamide textile blends waste to biopolymers and fibers.

Innovative approaches for recycling and upcycling of textile waste are required to sustainably treat the tremendous, discarded amounts. Due to their high specificity and mild reaction conditions, enzymes offer an environmentally friendly alternative for separation of blended materials. Glucose was recovered from cellulose (viscose) and polyamide blends and utilized as carbon source for biosynthesis of two biodegradable polymers. Polyhydroxybutyrate (PHB) was produced by *Cupriavidus necator* reaching an intracellular accumulation of 60 % (w/w) and 5.2 g/L of PHB from 20 g/L of glucose-rich hydrolysate. Bacterial cellulose (BC) was produced by *Komagataeibacter sucrofermentans* exhibiting equal properties to BC produced in standard media as confirmed by FTIR spectroscopy, SEM, and XRD. The recovered polyamide fibers were thermo-mechanically reprocessed and characterized by tensile testing showing comparable properties to virgin material. Thus, a combined bioconversion and mechanical reprocessing approach for textile waste is demonstrated allowing for recycling and valorization of each fraction of blended materials.

Chemicals of Concern

SCIRT Task 2.4 aimed to generate more knowledge on the (potential) presence of (certain) chemicals of Concern (CoC) in (thermos-) mechanically recycled textile. In short, six samples of recycled fibre produced within SCIRT and used to create demo garments by the SCIRT partner brands were analysed on REACH or OEKO-TEX® STANDARD 100 compliance.

All six demo samples were compliant with the legal requirements laid down in REACH.

For the four samples assessed for compliance with OEKO-TEX® STANDARD 100 Annex Class II (desired compliance for the brands):

- HNST cotton fibre samples and Petit Bateau cotton fibre sample complied with Annex 4 Class II.
- Xandres wool fibre sample did not comply with OEKO-TEX® STANDARD 100 Annexes 4 Class II.

The analyses **results were overall positive**. All samples were REACH compliant which is the most important requirement. With the exception of one sample (Xandres wool fibre sample), all other analysed fibre samples complied with the desired OEKO-TEX® STANDARD 100 Annex and Class. This is as well a positive result.

However, care needs to be taken in drawing definite conclusions on the presence of CoC in (thermo-) mechanically recycled textiles in general based on the analyses results. Based on the

heterogeneity of the recycled feedstock and the limited number of samples that were taken and analysed, the **representativeness** of these results remains to be established. Compared to the volumes produced overall in SCIRT only a very small amount of recycled fibres was chemically analysed. It is possible that concentrations in other samples would have been higher or lower, with different compliancy outcomes as a result. Drawing conclusive conclusions about the compliance of the demo end-product is therefore difficult.

Based on the limited number of measurements, the presence of CoC at least does not seem to be an issue. It is noted however, that product legislation will continue to evolve and in general become stricter to protect the consumer and the environment. These three elements will increase the risk of having CoC present in recycled material and make it more difficult to comply with the law.

SCIRT Task 2.4 has shown that the presence of CoC is currently not a pressing problem in (thermos-) mechanical textile recycling for the fibre types that were investigated (cotton, wool, polyester and viscose) and that the demo's would most likely fulfil at least the legal (REACH) requirements.

Webinar on CoC research and findings October 31, 2024. Sign up here.

True Costs Calculator

The True Cost Calculator, soon to be accessible on truecostcaculator.eu, is a freely available, self-assessment tool that enables the analysis of the ecological and social impact of a garment over the full lifecycle, in an efficient manner and understandable unit. The calculator complements and improves current analyses and frameworks to determine and quantify the environmental and social impact and costs of a piece of clothing along its complete life cycle. It distinguishes itself from tools available on the market today (either general or specific for the textiles industry) by going beyond quantifying external impacts of producing, transporting, using and disposing of textile products as well and providing default numbers for users that may not have the exact number or information necessary to enter into the calculator. Its main emphasis is on integrating the different impact dimensions (financial, environmental and social) and monetizing them. This allows for the identified external costs to be included in the pricing of textile goods and to compare different systems and set-ups. The calculator additionally considers lessons learned during the testing of the technologies used in SCIRT, resulting in clear, hands-on design guidelines for labels and manufacturers with regards to material composition, blends, used trims and additives. True Cost Calculator can be used by designers, buyers, CSR managers and consultants and well and fashion industry students. The calculator could eventually be applied to other sectors to evaluate and quantify the environmental and social impact of other types of commercial products.

True Costs Calculator: https://www.truecostcalculator.eu
Podcast on True Cost: listen here.

Criteria Enabling Circulation Validation Tool

SCIRT builds upon the circular.fashion Criteria Enabling Circulation Validation Tool, integrated in the Circular Design Software produced by circular.fashion, which supports user brands (large corporations and SMEs) in getting ready to comply with EPR, ESPR and DPP, with extraordinary trustworthy circularity experience. The tool provides criteria for circularity, to prepare for upcoming regulations. The B2B Guidelines enable circulation for brands, giving them easy and digestible information on changes required to prepare for upcoming regulations and go beyond their current sustainability standards to communicate efforts in a credible way. With the 'Enabling circulation' validation tool further developed through SCIRT, the objective will be to make the tool accessible through a subscription. With the tool integrated in circular.fashion's Circular Design

Software, users will pay a fee to access and use the tool. The SCIRT partner hopes to further scale the tool and help the industry in going beyond current limitations in circularity in textiles.