From Waste to Fashion

Exploring opportunities for bringing industrial polyester waste into the world of fashion

FILIPPA K

AXFOUNDATION

Axel Johnson International

A Circular Economy for Plastics

Economic development is driving increased demand for plastics due to their unique properties, various uses, and inexpensive price. But its linear production, use and disposal impose severely negative impacts on society and the environment. As a result, plastic pollution has become one of the most pressing environmental issues of today[1].

In Sweden only, around 1.6 million tons of plastic waste is generated every year of which less than 10 per cent is recycled. The remaining 90 per cent is incinerated and is causing 6 per cent of Sweden's greenhouse gas emissions[2]. Today's recycling capacity in Sweden can process a limited number of plastic products and packaging materials. The reason is that every new plastic-type to be recycled requires investments in new or developed production lines or processes. This requires considerable feedstocks of each specific plastic-type to make the investment economically feasible.

10%

Today, less than ten per cent of plastic is recycled in Sweden

Researchers have pointed out that humanity is now operating outside the planetary boundaries for novel entities, where plastic pollution has been highlighted as "a particular aspect of high concern"[3]. In a report from 2021, WWF concludes that the cost of plastic to the environment and society is at least 10 times higher than the market price paid by primary plastics producers[4].

As a response to these pressing issues, The EU adopted a European strategy for plastics in January 2018[5], which is part of the EU's circular economy action plan[6]. In 2022 Sweden followed suit and adopted a national strategy for plastics[7]. The strategy includes 55 measures to reduce the negative effects on society and the environment caused by plastics.

In 2022, the world moved closer toward a global agreement to end plastic pollution[8]. At the UN Environment Assembly in Nairobi, Heads of State, Ministers of environment and other representatives from 175 nations endorsed a historic resolution to end plastic pollution and forge an international legally binding agreement by 2024. The resolution addresses the full lifecycle of plastic, including design, production, and disposal.

We are now in a time where governments and businesses need to fundamentally rethink their plastics systems. Innovations in process and recycling techniques together with cross-industry collaborations will be key factors for a circular economy for plastics.

[1] Parker, L., 2019
[2] Ljungkvist Nordin H. et.al, 2019
[3] Persson L., de Wit C.A. et al., 2022
[4] WWF, 2021
[5] European Commission, 2018
[6] European Commission, 2020
[7] Regeringskansliet, 2022
[8] United Nations, 2022

Could industrial polyester be given a new life in the world of fashion?

Every year over 3 300 tons of polyester transportation and lifting products from the industry group Axel Johnson International enter the global market. The total Swedish market for these products is estimated to be over 1 400 tons. The products are made of high-strength industrial polyester to endure heavy lifts and security. However, these products have a short lifecycle, and in most cases, they are only used once or a couple of times before they get discarded due to logistics, safety, or insurance reasons. Because of the low price of virgin polyester together with the challenges of recycling these strong materials with today's conventional methods, the incentives to utilize these products are low.

About polyester

Material: Synthetic fibre derived from mixing glycol (derived from petroleum) and terephthalic acid. Often known as PET – polyethylene terephthalate

Use: Clothing, furnishings, textiles, bottles, industrial lifting, and cargo securing equipment, etc.

Today, most of the recycled polyester originates from used PET bottles

At the same time, there is an increasing demand for recycled polyester from the fashion and textile industry. Today, companies are heavily dependent on virgin plastics, with polyester having a market share of 51.5 per cent of the total global fiber production. The market share of recycled polyester is slowly growing and is now accounting for 14.7 per cent[9].

Today, recycled polyester is mostly made from plastic bottles. This is not a long-term solution for the industry since taking bottles away from the food industry, with its high requirements on food safety, is interfering with a closed-loop system. Hence, the fashion industry is looking for alternative feedstocks for recycled polyester.

In the project From Waste to Fashion Axfoundation, Axel Johnson International and Filippa K took on an ambitious goal: to take industrial polyester waste and give it a new life as recycled material in the world of fashion. The goal was to eventually develop a new ecosystem for polyester where the industrial polyester waste would be recycled and used as input material in the fashion industry and, ultimately other sectors. This would enable a reduction of waste from polyester transportation and lifting products as well as reducing the use of virgin polyester in fashion.

The project showed the potential for industrial polyester to be recycled and become a resource in an apparel value chain. But systemic challenges hindered the scaling of the solution. In this report, we share the project results and lessons learned.

[9] https://textileexchange.org/wp-content/uploads/2021/08/Textile-Exchange_Preferred-Fiber-and-Materials-Market-Report_2021.pdf

Understanding the demand

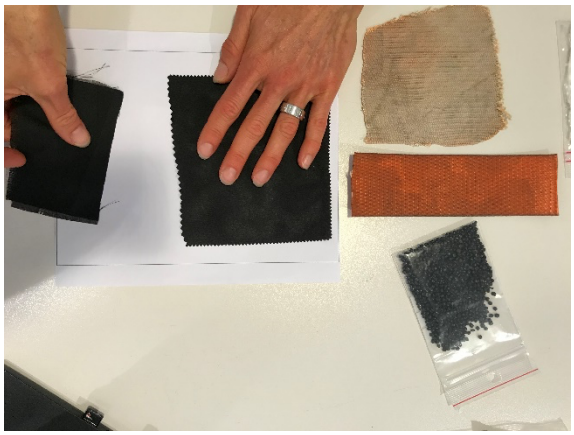
Firstly, Axfoundation mapped the demand for recycled polyester among Swedish fashion and outdoor brands. About 10 brands were interviewed to better understand the companies' processes of sourcing recycled polyester and their thoughts on the future of materials and more specifically, polyester. Axfoundation also explored the interest in the project and in buying recycled material originating from industrial waste streams. The brands showed a big interest in the project and its future results. A common denominator was the need to find new feedstocks for recycled polyester beyond PET bottles. Most of the brands already had strategies in place for the transition to recycled, biobased and regionally sourced materials.

Evaluating recycling methods for industrial polyester

After validating the demand for an alternative feedstock for recycled polyester, the next step was to evaluate the recyclability of the feedstock. The textile used for the transportation and lifting products from Axel Johnson International is made from 100% high-strength industrial polyester. For lashings, a steel component is added to enable the securing of goods. The used products are often contaminated with oil and dirt.

Despite the challenges related to toughness and contaminations, the project managed to develop a successful proof of concept together with Filippa K and their trim supplier in 2018: Industrial polyester waste was made into prototype buttons and buckles through a process of mechanic recycling. The plastic was shredded, washed, and drained before it was melted into pellets. The PET pellets were then prototyped as a potential feedstock in the production of buttons and buckles for Filippa K and were also tested in the production of fabric. The pilot project was carried out on a small scale but managed to show the potential for a circular solution where the industrial polyester waste could be recycled and become a resource in an apparel value chain.

The material was also evaluated by the Hong Kong Research Institute of Apparel and Fashion to examine the potential for fibre-to-fibre recycling. The conclusion from the first trials showed that their existing technology, developed for staple fibres like cotton, could not process the material in the same way due to its strong construction. But with further development of the technology for fibre-to-fibre recycling, this might be possible in the long term.



Prototypes of buttons, buckles and fabric

In parallel with the tests of mechanical recycling, the project participated in a RISE initiative, testing chemically recycling of polyester transportation and lifting products by depolymerization. The output after a chemical process is a pure monomer, which can be used as the building block for new PET plastic with the quality of virgin polyester. The initial tests showed promising results. Contaminated

transportation and lifting products were successfully recycled, on small scale, to virgin quality rPET. An early LCA analysis also suggested that the recycled PET had a 72 % lower CO_2 impact than virgin polyester. However, these tests were carried out on a lab-scale but with the growing interest and upscaling of chemical recycling technologies for polyester in Europe, this could become a viable solution in the medium or long term.

There are many different recycling methods for plastics, and they all come with their unique advantages and challenges. In general, mechanical recycling, compared to chemical, has the advantage of consuming less energy and having a less negative impact on the environment since it requires fewer steps to get the material back into the user phase[10].

When it comes to chemical recycling, the term refers to a diversity of processes and technologies that transform waste plastics into like-new materials. That is also the main advantage since it enables the recycling of complex and contaminated plastics without downcycling the material[11].

Mapping the waste stream and business modelling

After proving the materials' recyclability, the project aimed to demonstrate the scalability and business case in utilizing the polyester waste streams. Data was collected by interviewing the companies within Axel Johnson International and a couple of their main customers. The project mapped waste volumes and flows, and activities along the value chain, and estimated potential financial gains from utilizing the material. Furthermore, systemic obstacles and challenges, as well as success factors, were identified.

The results showed that every year, Axel Johnson International's companies alone distribute polyester which equals three per cent of the consumer plastic packages collected in Sweden yearly. The financial loss from not utilizing these materials was estimated at 13 - 28 million SEK. The business modelling further concluded that these materials represent a pure PET fraction. A promising mono-material, fit for a circular solution. From an environmental point of view, the analysis concluded that 5.2 tons of CO_2e would be saved per ton of virgin polyester that is replaced with recycled polyester.

5.2 tonnes of CO_2

...could be saved per ton of virgin polyester that is replaced with rPET.

However, major systemic challenges were addressed that obstruct the possibilities to create change. The waste streams occur irregularly, in small volumes, and in countless geographical locations. The condition of the materials varies greatly which requires pre-treatment before recycling. The lack of processes and infrastructure that would enable a large-scale collection and handling calls for collaboration with downstream actors such as logistics and recycling partners.

[10] Naturvårdsverket, 2021

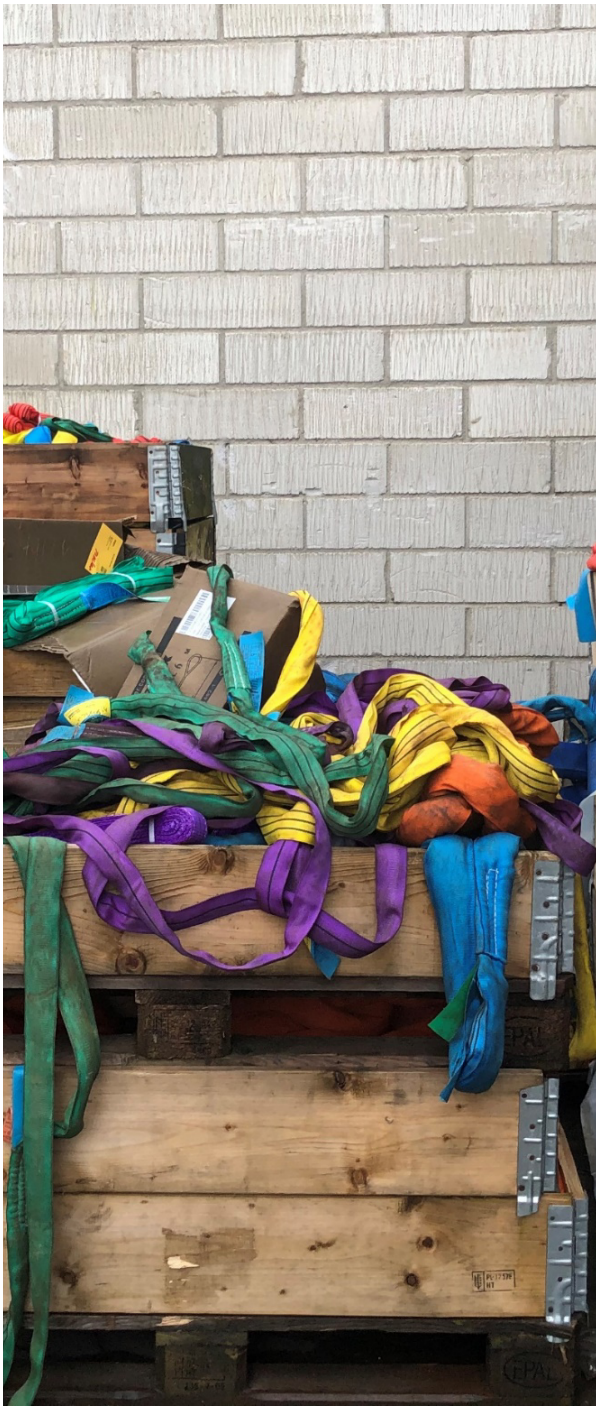
[11] Naturvårdsverket, 2021

Finding the right partners for scaling

As a result of the business modelling, the project reached out to several key downstream actors in logistics and recycling. The purpose was to team up to collect and prepare the waste materials for recycling. Unfortunately, these dialogues did not move forward since the volumes were considered too small for them to be profitable to recycle.

Disappointed with this result, the project decided to participate in the research project “Smart Loops”. This research project, led by IVL, aimed to evaluate whether it is possible to have a specific collection and get smaller, but cleaner flows, so-called "Smart loops" of materials in Sweden. The most challenging obstacles for smart loops were identified as (1) finding the right buyer due to many uncertainties about the material (2) policies limiting the market for waste material flows (3) lack of plastic knowledge along the whole value chain to handle and process the material, (4) need for behavioural change to secure the right collection and handling and (5) the pressing need for increased collaboration across value chains and sectors to realize smart loops. You can read the full report here.

From Waste to Fashion also evaluated two digital marketplaces for second-hand materials to connect with potential buyers on the European market. Limitations of the first platform made the creation of products passport time-consuming and complex. Together with indications from a second service provider that the market is still too immature, and the number of potential buyers for the material stream would be very limited, the project decided to not take the next step in the process. However, with the planned introduction of digital product passports on the European market[12] together with other policy interventions and an increased capacity for reverse logistics - the time for digital marketplaces for secondary raw materials can be here sooner than we might think.



[12] European Commission, 2020

Lessons learned

The project's ambitious goal of taking industrial polyester waste and giving it a new life in the world of fashion turned out to be a challenge. In the first phase, the project showed the potential for industrial polyester to be recycled and become a resource in an apparel value chain. But in the second phase, systemic challenges hindered the scaling of the solution.

The project has identified five key levers to enable a circular business model for industrial polyester.

1. Innovation and scaling of recycling technologies

Firstly, there is a need for investments and policies to boost technological innovation, and scaling of existing technologies. These must be suitable for the pre-treatment and recycling of "problematic" and smaller feedstocks of plastics, including high strength and contaminated industrial polyester. Today's recycling manufacturers are not set up to handle these types of products and can only process a few different plastics with even quality and volume. These volumes also need to be significant to be financially justified for recyclers to be interested. The project has identified this lever as the most stressing one to enable the recyclability of industrial waste plastics. Throughout the project we have had several interested buyers in the materials, but these conversations have been obstructed due to the lack of large-scale, practical, and economically feasible pre-treatment and recycling solutions.

2. Sustainable solutions for reverse logistics

Secondly, the development of recycling technology also needs to be supported by sustainable solutions for reverse logistics that could handle irregular, geographically spread, relatively small and uneven flows of materials. In the use cases the project addressed, there was a lack of collection systems and quality controls of the waste volumes generated. Furthermore, behavioural change among users of these products is needed to support the reverse logistics system. Some of the products are also a challenge due to their size and weight of over 100 kg. In summary, today there is a lack of processes and infrastructure that would enable the collection, pre-treatment, and recycling in an economically, environmentally, and socially sustainable way.

3. Information about the composition and recyclability of secondary materials

Thirdly, there is a need for increased traceability and access to digital data regarding the composition and recyclability of goods so that users across the value chain more easily can reuse them or treat them correctly at recycling facilities. The project did have access to data on the industrial polyester waste, but a digital product passport would have eased and simplified the dialogue with potential buyers and downstream actors.

The European Commission is planning to introduce digital product passports that would serve as a "digital twin" and inventory of all materials, components and raw materials used in a product[13]. Our results suggest that this has the potential to increase the chances of secondary materials being returned to the value chain and properly recycled at the end of their lives. Through the digital twin, value chain actors get access to a common language and the same information about the material. In Sweden, the Delegation for Circular Economy has suggested several measures to increase the traceability of,

[13] European Commission, 2020

and demand for, secondary material. This includes an investigation of the differentiation between virgin and recycled plastics and increased use of recycled materials through quota obligations and recycling certificates, as well as the development of national data on material streams to support decision making and monitor progress[14].

4. Partnership

The creation of sustainable value chains for the recycling of industrial polyester and other challenging plastic waste streams calls for collaboration: both across the value chain and between industries.

Today, downstream actors consider the volumes too small to be profitable to recycle, even in the case where tons of the material were consolidated in one location. The technical limitations call for large investments in processes and infrastructure – a cost difficult to hold for a single actor in the value chain. Hence, joint efforts are requested to find solutions for increased recycling capability.

5. Right economic conditions for the secondary raw material market

Finally, the project found today's low price for high-quality virgin plastic to hinder the right market conditions for recycled polyester. The price is not only holding back the demand for recycled alternatives (due to the recycled alternatives' hard time competing with their virgin counterpart in price), but also the investments in technology and infrastructure needed to enable the recycling of industrial polyester on a larger scale[15].

What happens next?

Axfoundation is leading multiple initiatives with a circular economy focus, and the systemic challenges that we experienced in this project are like what we have found in other projects. We believe that the key levers identified in this project are not only supporting the development of circular model for industrial polyester – but the transition to a circular economy in general.

The systemic challenges are not likely to change overnight. But with the current development of policy, technology, business models and infrastructure supporting the transition to a circular economy, the rules of the game are inevitability changing. As a result, the governments and businesses that are already rethinking their plastics systems are far better positioned than those continuing as it was business as usual.

This report summarizes the results and lessons learned from the project From Waste to Fashion, but Axfoundation's, Axel Johnson International's and Filippa K's engagement does not end here and the dialogue with potential partners around the co-creation of a new ecosystem for recycled polyester continues.

[14] Delegationen för cirkulär ekonomi, 2022

[15] WWF, 2021

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