

XXI International Conference on Industrial Engineering and Operations Management
9th International Conference on Industrial Engineering and Industrial Management
International IIE Conference 2015
Aveiro, Portugal. July 6-8, 2015

Current Trends in Recovering Used Products in Retail Fashion Industry: An Exploratory Study

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Abstract Fashion industry is currently shifting towards sustainable practices through the entire supply chain. Many fashion retailers like H&M, Zara and others consider sustainability the cornerstone of their corporate social responsibility programs. At the same time, Extended Producer Responsibility (EPR) legislation is holding manufacturers and retailers responsible, especially in Europe, for waste generated at end-of-use and end-of-life phases for some specific products. Finding alternatives to the landfill for textile waste will extend textile life, contributing to the development of circular economy and sustainable business models in the fashion industry. This study identifies and characterizes, as a first stage research, current practices of product recovery for used textile in France and Germany using comparative case studies. Characterizing the reverse logistics models for textiles in each country will help identifying best practices for recovering used clothing in Europe.

Keywords: Reverse logistics, fashion industry, textile waste, product recovery, take-back

1 Introduction

Fashion industry, as a relevant agent contributing and impacting our economy, societies and the environment, requires more research and development towards circular economy and sustainability-based models. Millions of tonnes of textile waste, such as fabrics and fibers, end up in landfills or incinerators every year.

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The technological and business-model revolution in fashion industries in the late 20th century has contributed to increased environmental effects by establishing more factories, producing more goods, and creating global-sourcing based models associated with disposable fashion that designers deliver to a mass market at relatively low prices and quality. Every year consumers buy new garments not only because their old ones are worn out, but because they seek to satisfy their desire of buying fashionable products. Fashion retailers attract us by offering and selling a wide variety of styles, colors, and materials at affordable prices. According to American Apparel and Footwear Association (AAFA, 2015), an average American bought around 68 garments and 7 pairs of shoes in 2011. The European Commission reports that EU consumers discard 5.8 million tonnes of textiles every year: only 1.5 million tonnes (25%) are being reused or recycled by charities or industrial enterprises, while the remainder ends up in landfills or incinerators (Beasley & Georgeson, 2014). In the UK, according to the Waste and Resource Action Programme (WRAP, 2012), about 350,000 tonnes of used clothing (worthing €180 million) are sent to landfills each year.

In other words, we are generating millions of tonnes of waste clothing and disposing billions of Euros in landfills every year. Are there other options for apparel waste streams? Product take-back practices establishing reverse logistics channels, closed-loop supply chains and circular economy business models are already being developed for specific products in some countries, with the aim of keeping the environment healthy by reducing, reusing and recycling. Some fashion retailers such as Patagonia, Puma and H&M have already started their journey to environmentally sustainable business models by selling ecological garments, donating clothing, using recycled materials for manufacturing new products, and planning for having their closed-loop line of products.

France is the first and only country to legalize a take-back system for textiles, linens and shoes. Although the government has enacted suppliers, producers, and retailers to collect post-consumer products, it is still collecting and recovering less than a half of other developed countries like Germany and Netherlands. In fact, Germany's waste recovery rates are the highest in the world and it is generating from the total waste recovery an annual turnover of 50 billion Euros (Wrap, 2012). Germany has an Extended Producer Responsibility EPR program for some products but clothing and shoes are still not included in the national legislation. In this study, we explore and analyze the reverse logistics process of the retail fashion industry, including collection, sorting and recycling. In addition, potential actors, drivers and barriers are reviewed and considered since they affect the RL implementation. By comparing different RL programs and practices we can identify the best product recovery practice for fashion industry.

Table 1 Quantity of textile collection in some countries in (La Fédération de la Maille & de la Lingerie, 2014)

| Country | Inhabitant (millions) | Total Collection (Tons/year) | Collection (Per Inhabitant/year) |
|---------|-----------------------|------------------------------|----------------------------------|
| Benelux | 27 | 150 000 | 5.5 kg |
| Germany | 82 | 700 000 | 8.5 kg |
| USA | 302 | 1 500 000 | 5 kg |
| France | 65 | 162 000 | 2.5 kg |

2 Objectives and Methodology

This study is exploratory and it aims to characterize the reverse logistics system of the fashion industry in Europe. The specific objectives are to answer the following research questions: How and why is the recovery of apparel done? What are the processes and facilities involved in the RL system? And what is the best recovery practice existed throughout fashion retailing?

The study will be based on desk research (literature review) using secondary data sources such as journal papers, news, magazine press, official national legislation, and technical and working papers. In addition, fashion retailers and textile companies' websites have been examined for analyzing their annual reports and publications. This case research will provide two descriptive scenarios for product recovery of used clothing. Two case studies are developed in this research to discuss and analyze the current practices for waste clothing collection, recycling, and re-distribution in two European countries. France and Germany have been selected to illustrate two different initiatives, approaches, motivations and actors for collecting used clothing. France is the first and only country in the world that issued extended producer responsibility (EPR) policy for used clothing. Yet, Germany's waste recovery rates are the highest in the world and it is generating from the total waste recovery an annual turnover of approximately 50 billion Euros (WRAP, 2012). Although Germany has EPR programs for some products, clothing and shoes have not been included yet in the legislation. Comparing both reverse logistics models in these countries would not only lead us to understand the overall reverse logistics system for each country but also allow us to identify best implemented practices.

3 Recovery of End-of-Use Fashion Products

End-of-use apparel and footwear (A&F) recovery involves the following sequential activities: collecting used items; 1st stage sorting for taking out re-wearable items; 2nd stage sorting for determining the potential for the product's reuse; cleaning; recycling processes; various treatments; re-distribution; and disposal as municipal solid waste in incineration or landfill. This study will follow the investigation module shown in Figure 1.

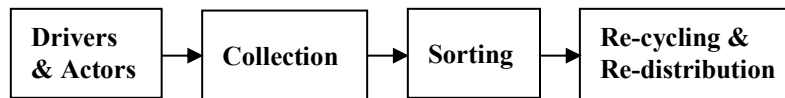


Fig. 1 Investigation module for describing the case studies (Own development)

Identifying the drivers and actors for product recovery will address the question of who is recovering used textile and why? On the other hand, identifying the collection, sorting and recycling schemes along with the reverse distribution channels would address the question of How is it done? By answering those questions, we can investigate later to improve and design efficient and valuable reverse logistics network. The framework we put forward in Figure 1 has been used for analyzing the case studies developed in Sections 4 and 5. In those case studies we research the take-back system for apparel and footwear in two European countries. Using a common framework for analysis enables us to develop a comparative analysis that is presented in Section 6 Discussion and Conclusions.

4 Comparative Case Studies: the French System

Drivers and Actors

In France, the Extended Producer Responsibility (EPR) policy for the apparel industry was introduced by the *Article L-541-10-3 of the Code de l'Environnement*, which came into force on 1st of January 2007. Since that date, according to the new legislation, all legal entities introducing in the French market new textile apparel products, i.e. garments, footwear and household linen, are hold responsible for the recycling or proper disposal of the waste generated by those products. Those entities (which include manufacturers, importers and distributors) can accomplish this legal obligation through two distinct ways: either by financially contributing to an accredited Producer Responsibility Organization (PRO) or by setting-up an individual take-back program approved by the French public authorities (Figure 2). Publication of the decree in the Journal Official specifying how to implement the law and the need of establishing eco-organization (PRO) took place in June 2008.

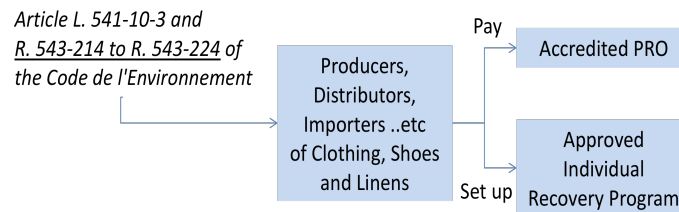


Figure 2 - Waste Policy for Textile, Shoes & Linens in France, own development

The authorized PRO must work in compliance with the provisions of the specification to fulfill the following obligations: help to prevent the production of waste TLC; promote, through information, awareness-raising and communication, the development of separate collection of waste TLC; contribute financially for sorting and recycling in addition to improving these activities; conduct information, awareness and communication on the recovery of used TLC; lead and support projects and research studies and project research to improve the performance of this sector, including the development of new markets and the improvement of recovery operations to minimize the system cost.

Therefore, a PRO for textile, footwear and linen was created in December 2008, Eco TLC (*Eco-organisme du textile, du linge et de la chaussure*), which is for the moment the only PRO accredited by the French public authorities to cover the sector. Eco TLC is a non-for-profit private company initially constituted by 29 associates (*associés*). The associates represent the whole textile value chain and are organized in five “colleges”: (a) general large retailers (e.g. Auchan, Carrefour, Monoprix); (b) fashion retailers (C&A, Galeries Lafayette, Etam); (c) direct sales and mail/online retailers (Damart, Groupe 3SI); (d) manufacturers and wholesalers (LVMH, Cotonflor-linge du lit); (e) apparel industry associations (Federation Nationale de l’Habillement, Union des Industries Textiles). The Board of Directors of Eco TLC is made up of 12 representatives chosen among the associate companies.

Apparel manufacturers, importers and distributors can register as members (*adhérents*) of Eco TLC in order to fulfill their EPR liability. Membership involves paying an annual contribution to Eco TLC, based on the last year’s volume put on the market, and transferring the member companies’ responsibility to the PRO. Currently, there are around 4967 members of Eco TLC represent 93% of the industry and they are listed in the PRO web site (<http://www.EcoTLC.fr/>).

The funds raised by members’ contributions are used by Eco TLC for covering the operating costs of the product recovery system; for funding R&D projects on the field of used apparel collection and recycling; and for supporting awareness-

raising campaigns organized by local authorities to encourage apparel waste sorting at household level.

The tariffs for members' contributions are recalculated every year, depending on the financial needs of Eco TLC. Members' contributions are received in the first quarter of year n and are based on the number of units (and their size) put by each member company in the market during year $n-1$. Tariffs consider four different sizes for garments and linen (very small, small, medium and large items) and two sizes for footwear (small and medium items). In order to incentivize the use of recycled fibers by the members, products that have a proven minimum of 15% of post-consumer recycled fibers can benefit for the "Eco-Module Tariff", which represents 50% discount over the normal tariff (Table 2). Member companies that have sold less than 5,000 items in year $n-1$ or whose revenue is under €750,000 are entitled to contribute a fixed tariff of €33 plus VAT.

Table 2 Eco TLC tariffs for 2015 members contribution ($n-1=2014$) (Eco TLC, 2014)

| Garments & Linen | Examples | Regular Tariff (€) | Eco-module Tariff (€) |
|-----------------------------|----------------------------|---------------------------|------------------------------|
| <i>Very Small Item</i> | Socks, kids underwear | 0,00121 | 0,00060 |
| <i>Small Item</i> | Shirts, leggings, lingerie | 0,00484 | 0,00242 |
| <i>Average Item</i> | Pijamas, nightdress | 0,00726 | 0,00363 |
| <i>Large Item</i> | Adult's jacket, coat | 0,0484 | 0,0242 |
| Footwear | | | |
| <i>Small Item</i> | Slippers, mules | 0,00484 | 0,00242 |
| <i>Average Item</i> | Shoes, boots | 0,00726 | 0,00363 |

The Ministry of Ecology, Ministry of Industry, the Ministry for Local Government (interior and decentralization) and the ADEME are the main actors of national policies affecting the TLC waste management. The main players involved in recovering used TLC are: consumers who need to contribute and dispose their used TLC in the specialized containers; local authorities, who raise awareness to their fellow citizens, coordinate the collection and incentivize enterprises for recovering used TLC; the primary merchants (manufacturer, distributor or importer) who sell on the French market new clothing, linens or shoes; Collection agencies which manage and transport collected used TLC in addition to providing drop-off collection points, door-to-door and surplus collection services; Secondary merchants and second hand stores who select the "cream" of used TLC and resell them to the shops of associations, thrift stores and recycling plants; sorting industries which sort used TLC and aim to maximize the recovery and meet the market demand by reusing and recycling; recyclers which transform un-wearable materials into secondary materials to be used for manufacturing new products; and eliminators which treat non-recoverable materials to be incinerated or land filled.

All players in the TLC sector are linked by an integrated information system to monitor: the flow of products and materials; the financial flows; common interests

to meet the challenges of sustainable development (environmental, economic and social); and the function and performance of the sector.

Also, there are many associations that work closely with local authorities to evaluate the current recovery activities of TLC and drive up local issues to ensure and promote the best waste management at local and national level. There are general associations such as *Association des Maires de France* (AMF) and *Assemblée des Communautés de France* (AdCF); and specialized associations such as AMORCE National Association of communities, associations and companies for waste management, energy and heat networks. AMORCE currently represents total of 825 members (553 local authorities and 272 professionals) and is a key player in the management of waste for local and national authorities. There are also associations of consumers and environment protection which represent civil society and consumers to discuss social issues and increase people awareness for evolving professional practices and individual behaviors in waste management of used TLC (e.g. France Nature Environment (FNE) and Zéro waste France).

In 2012, 2400 million pieces were put on the market and 14 million Euros were collected from the members (an average of 0.05 euro per unit). This contribution was used and distributed as follow: 2 million euro (8%) was paid for taxes, staff, offices, and outsourced services; 250,000 euro (2%) was paid for research and development; 3 million euro (25%) to cover collection and logistics services; and 9 million euro (65%) was for sorting and recycling enterprises.

Collection

Every year, the amount of collected textiles and footwear in France is increasing. In 2006, the amount of collected articles was 65,000 tonnes. In 2011, 140,000 tonnes (2 kg/person) of used textiles were collected (*La Fédération de la Maille & de la Lingerie*, 2014). Eco TLC reported that around 600,000 tonnes (10 kg/person) of clothing (80%), linen (8%) and footwear (12%) are put into the French market every year (Tirad, 2013). France has set 50% (4.6 kg/person/year) as a collection target for clothing, linens, and footwear to be reached in 2019 as a part of the national waste prevention program of 2014-2020. Thus, every year more collection organizations are involved in the process in the hope of achieving more collection. Presently, there are 150 collection operators representing more than 35,000 collection points. Eco TLC pays for each collection point *Point d'Apport Volontaire (PAV)* that reaches 2000 inhabitant coverage. The collection is financed by the resale market for second hand or recycling. After use, apparel can be dropped off either in stores (e.g. H&M) or in special designated containers. Consumers can find the containers in the street and in recycling centers. Cleaned clothing should be separate than dirty one and both should be placed in a plastic bag of 50L size or smaller. The pair of shoes needs to be tied so that will not get separate during sorting. To help consumers locate the closest drop off place, Eco

TLC has launched a mobile application and interactive website for this purpose also to raise the customer awareness regarding the textile waste prevention. Other collection schemes are also available for so that items can be collected door-to-door from partner charities or households. It has been reported that the volume collected through containers is about 46%, whereas charities and households collection represent 36% and 18% respectively (La Fédération de la Maille & de la Lingerie, 2014). All collected products are then transferred to sorting centers to where items will be examined and sorted according to their serviceability, quality and conditions.

The national territory is covered up by 1 voluntary contribution point (PAV) per 1840 habitants in 2015. Only twenty departments do not reach the level of 1/2000 inhabitants. There is a target to increase the collection points to reach 1 per 1500 inhabitants to make it more convenient and accessible to the citizens who want to dispose their used TLC.

A "Voluntary Contribution Point Holder" (DPAV) is the person or entity holds a voluntary contribution point (PAV) at the address mapped in the database of Eco TLC. They should get a permission and be authorized to install the PAV on site. A "collection operator" is the agency which provides the pickup and logistics from the PAV to the sorting facilities. It can also be "Holder of Voluntary Contribution Point". The DPAV and collection agencies gather various actors such as: associations and professional and non-professional sorting agencies. Holders of voluntary contribution points and logistics providers should manage the recovery of used TLC by providing contribution points and other collection services for picking up the items from associations or shops or door-to-door from charities under the Social Solidarity Economy, private companies and local communities.

Table 3 Collection channels implemented in France and their performance (Eco TLC, 2015)

| Channels | Collecting % | Examples |
|----------------------------------|---------------------|--|
| Containers accessible 24 hrs | 69 | Curbside bins |
| Containers with a limited access | 22.5 | Apparel stores and recycling center |
| Donation to associates | 7 | <i>La Fédération Nationale de l'habillement</i> and <i>Union des Industries Textiles</i> |
| Return to shops | 1 | Apparel Stores and supermarkets |
| Door-to-door | 0.5 | From Charities under the Social Solidarity Economy |

The agreement of DPAV with Eco TLC allows them to be integrated into the recovery sector and be identified with other stakeholders and professionals to increase the traceability of each one. As a PRO, Eco TLC is responsible to provide the DPAV a free kit for standardized and customized system to monitor and locate their PAV in a geographical map that can be easily accessed by the public and local authorities. On the other hand, DPAVs are committed to: provide and update the geographical positions of their PAVs; declare the tonnage of collected TLC and destinations so that traceability can be achieved to monitor the materials flow; and to use the common logo and symbols provided by Eco TLC to increase public awareness.

In 2015, 600,000 tonnes are put in market and the collection is estimated to be 175,000 tonnes. Eco TLC lists 272 DPAVs in the website and there are 35,373 PAVs in France. The collection takes place through voluntary contributions of TLC where consumers can dispose their TLC in local branches of association, in containers located in streets and parks, inside stores like supermarkets, apparel stores and recycling centers, or other collection events such as door-to-door collection and occasions prepared by charities and second hand sale.

Sorting

Eco TLC is financially supporting sorting and recycling businesses fulfilling the required standard and work conditions. In 2014, 60 European sorting companies were involved (45 facilities were French). Those enterprises should report to Eco TLC the amount collected and how has been reutilized and recovered. Sorting is very critical phase and it requires trained persons because it is done manually and it is where decision needs to be made to choose the items destiny. The first stage of sorting will separate the re-wearable clothing and shoes and re-useable linens manually from the ones which need further treatment. So that the re-useable products will be either locally re-sold in second-hand shops or re-sold and export to other countries (mainly developing countries). The second stage will involve removing the hard particles from the products and resorting according to the fiber length, color and quality. In fact, 60% of used articles end up for “re-wear”, 30% are for “recycling”, 5% are to be land filled, and 5% are incinerated for energy production. Part of “good-condition” clothing is given to the people in need or sold at a low price while the remaining is sold to different traders. (Tirad, 2013)

Eco TLC provides financial support to sorting operators (€ 65/ton for material recovery, € 20/ton for energy recovery) when they comply certain conditions (table 4) to enable them to: improve their businesses; increase their sorting capacity; and optimize the sorting and recycling output. Additionally, it evaluates the development of sorting and employment status so that it financially supports sorting operators from 50 € to 125 € per ton when efforts are made to increase the sorting capacity as well as hiring workers who have difficulty finding jobs (Table 5).

Table 4 Sorting conditions which need to be met for receiving financial support from Eco TLC (Eco TLC, 2015)

| Sorting Performance Required |
|--|
| material recovery rate > 90% |
| Recycling rate (unraveling or wiping) > 20% |
| Elimination rate without energy recovery: 5% maximum |
| The operator must develop 90% of collected TLC |

Table 6 Qualifications of Sorting agencies for receiving financial support from Eco TLC (Eco TLC, 2015)

| Financial support | Qualifications |
|--|--|
| (€ 65/ton) for material recovery | Being a separate legal entity |
| | Respect <i>la réglementation en matière de protection de l'environnement</i> (ICPE in France) |
| (€ 20/ton) for energy recovery | Ensure traceability in upstream (including collection) and downstream (including export) of the sorted materials |
| | Achieve the sorting performance level defined by the authority |
| | Ensure financial transparency of its accounts |
| 50 to 125 € per ton | Efforts are made to increase the sorting capacity |
| | Integrating and hiring workers who are in difficult social situation |

Eco TLC has built a strong product management system to trace all actors in the process to measure and monitor the collected TLC flow from each PAV up to the final destination described by type of recovery and disposal, by country and by customers.

Clothing is sorted into different categories to be re-used for different purposes: The cream of the material “high quality” will be re-used and sold in second hand market in France or internationally; lower quality clothing will be re-used and sold in lower class market; Unusable clothing will be recycled to produce cleaning cloth or other materials used in different industries; and the remaining materials will be disposed in landfill or incinerator.

Recycling and Re-distribution

Mechanical recycling is widely used in France. Recycling of textile includes one of the following different processes: unraveling, grinding, defibrating, and cutting. Any recycling operation requires first removal of hard particles like but-

tons, zippers and rivets. The most common processes are unraveling and cutting where the outcome for unraveling can be nonwoven fabric, flock and new yarn and for the cutting are the rags (Table 6) (Tirad, 2013). The market of the wiping clothes (rags) is important since 20,000 tons per year are produced in France. Also, clothes are cut into coupons to be reused as a patchwork to apparel and furniture industries. The grinding operation is used to produce short fibers or powders that can be used in plastic industry. Defibrating process is still under development to increase the fiber that can be re woven into new textiles. The overall rate of recovery of TLC Used in 2013 reached 94 % on average and the reutilization of the recovery is shown in table 7 (Eco TLC, 2015).

Table 6 The amount of each main recycling process and their output customers in 2013 (Eco TLC, 2015)

| Recycling process | Amount % | Market | | |
|-------------------|----------|-------------|-------------|------------------|
| | | In France % | In Europe % | Outside Europe % |
| Unraveling | 65 | 31 | 41 | 28 |
| Cutting | 30 | 44 | 38 | 18 |

Table 7 The TLC recovery and redistribution in 2013 (Eco TLC, 2015)

| Reutilization | Amount % | Market | | |
|---------------|----------|-------------|-------------|------------------|
| | | In France % | In Europe % | Outside Europe % |
| Re-wear | 61 | 10 | 13 | 77 |
| Recycling | 33 | 37.5 | 39.5 | 23 |
| Elimination | 6 | NA | NA | NA |

5. Comparative Case Studies: the German System

Drivers and Actors

Germany is one of the top five European countries in terms of textiles and clothing production (WRAP, 2012). It is also ranked the first in Europe in term of collecting the largest quantity of textiles per year and it is the first in the world in terms of collecting the maximum quantity of textile per person per year (WRAP, 2012). Germany is practicing the collection since many decades ago collaborating with charities, churches, and commercial enterprises. The waste hierarchy of prevent, recover, and dispose was introduced and recognized for different products, including textiles, in the 80s decade, under the Closed Substance Cycle and Waste Management Act, which finally came into force in 1996. According to this Act, owners

and generators of waste are responsible for waste avoidance, recovery, and disposal. However, although Germany has EPR programs for some products, clothing and footwear are not included in the legislation.

In this study, one commercial enterprise in Germany, SOEX Group, will be investigated because of their innovative partnerships programs for textile recovery. The company was established in 1977 as a private company intending to become a global market leader in collecting, marketing, re-use and recycling of used textile maintaining ecologically-sustainable practices. SOEX currently employs 2100 people working worldwide and exports used textile to around 90 countries in Asia, Africa, Europe, and North and South America.

Collection

The unique collection system hold by SOEX Group has attracted shareholders, charities, and fashion retailers. SOEX aimed to collect more used apparel and decided to integrate with well-established logistics companies to handle the reverse distribution inside and outside of Germany. Many acquisitions and partnerships agreements took place with independent companies (e.g. EFIBA, Retextil, ERC, and NTA). EFIBA collects mainly from charitable partners (70%) and they have 22,000 collection bins distributed throughout Germany. Every year, Soex purchases 90,000 tonnes of clothing from The Red Cross in Germany in addition to 36,000 tonnes from the Salvation Army, Goodwill and Rescue Mission in the United States. In 2012, Soex total collection for used clothing and shoes was 146,000 tonnes (Soex Group, 2014). The company has established an innovative organization called I:CO to manage a new collection line working with fashion retailers globally.

I:CO, which stands for I:Collect, is a unique system for collecting garments in stores and then processing them for recycling. I:CO is marketing SOEX innovative sorting system and their utilization channels for used products to leading fashion retailers such as The North Face, H&M and many others, and establishing long-term partnerships with them. All fashion products, including leather clothing and furs, underwear and socks, belts and bags, bed, table and household linen and cushions, are collected in the designated I:CO boxes inside retailers' stores. Customers will obtain a reward shopping voucher depending on the total weight that has been scaled. The total capacity of I:CO box is about 6 Kg. When the box is full, the store seals the shipping box and brings it to the store shipping area to be ready for pick-up. Then, all collected items in Europe will be delivered to SOEX's Wolfen sorting facility for sorting and recycling.

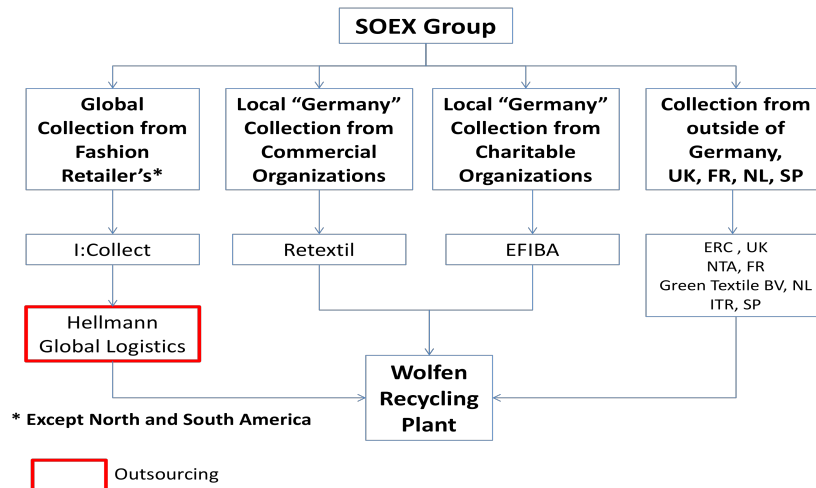


Figure 5 – SOEX Group Collection Schemes, own development

Sorting

Soex Group has two sorting and re-cycling centers located in Germany and in the US. Wolfen plant, founded in 1998, is considered one of the largest sorting facilities for used textile and clothing in Europe. It has an area of 89,000 m² where 700 employees are working in 3 shifts to sort 400 tonnes of garments every day. Collected articles will be scaled and registered before passing into the sorting processes: Separation (where shoes, residual waste, and bed feather are separated); presorting (garments are sorted per clothing type, e.g. pants, T-shirt, etc.); and fine sorting according to the quality of wearable clothing. Trained staff is sorting the used items according to 350 different criteria to suit fashion aspects and different client-oriented criteria. It has been reported that 60% of the collected articles are re-wearable (10% of clothing is in good shape and 50% is not but still re-wearable). 15% is re-used in textile industry to produce wipers. Around 20% is recycled to be used as filling or insulation materials to different industries. Finally, 5% is to be incinerated. (Mzikian, 2013)

Recycling and Re-distribution

The recycling system of SOEX is also mechanical which is used to make products that are similar to the one discussed in the French case. 15,000 tonnes are processed and recycled every year to create fleece materials that can be used in producing insulating materials and protective sheeting for painting. Single color t-shirts and sweatshirts that can be worn are converted into wiping cloths in-house. In addition, wearable items that are in good condition would be up-cycled and re-designed to be unique and one of a kind fashionable pieces. SOEX owns two sec-

ond-hand clothing businesses to sell high quality used clothing: Cash4brands and Modemarkt Freestyle GmbH. Cash4brands is an innovative online platform for selling name-brand and designer clothing while Modemarkt Freestyle GmbH has branches in Hamburg, Munich and Berlin offering a large selection of second-hand clothing and trendy vintage fashions from the 60's, 70's and 80's. 10% of the output of sorting and recycling is sold in Germany; 47% is sold in Africa; 26% is sold in the Western Europe; 14% is sold in the Middle East; and 3% is sold in Asia and America. (Mzikian, 2013)

6 Discussion and Conclusion

France has obligated the fashion producers to recover used clothing implementing EPR policy to encourage more collection of used textile and footwear. Unfortunately, the collection rate per year in France is still very low comparing to other European countries. The collection rate in France is only 2 kg/inhabitant/year while in Germany the collection rate is 8.5 kg/inhabitant/year (*La Fédération de la Maille & de la Lingerie*, 2014). The key success of German collection has been achieved by long term effective plan that allowed shareholders and charities to participate in this trend to turn the waste into valuable resources. In addition, the reverse distribution system seems to be an important factor for the success of SOEX Group and Germany which will be investigated in the next stage of our study. The SOEX Group practice for apparel recovery is the best in Europe in terms of the number of fashion retailers involved and the unlimited type and quality of used apparel collected and recycled.

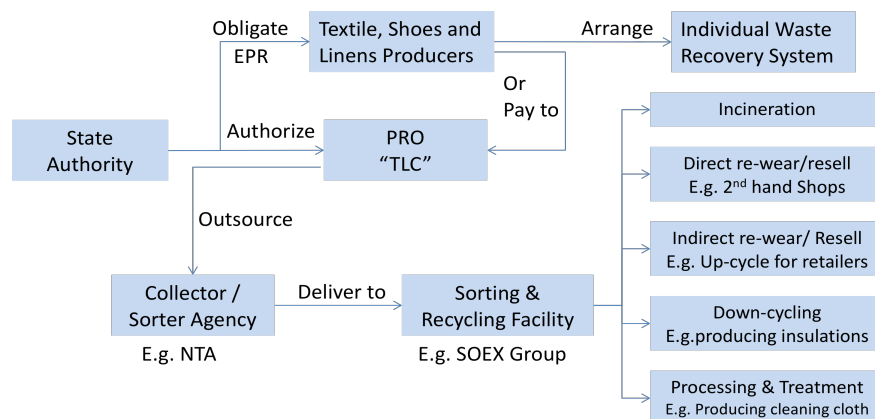


Figure 3 - Textile Waste Scheme in France, own development

Table 8 – Recycling processes and objectives, own development

| Recycling Process | Use / Industry |
|-------------------|--|
| Cutting | - Patchwork cloth for clothing, furnishing and decoration markets - Wiping cloth for industrial and household use |
| Unraveling | - Geo-textile for civil engineering applications - Phonic insulation for automobile industry - Phonic and thermal insulation and filling for construction industry |
| Defibrating | - Recycled fiber for clothing industry |
| Grinding | - For plastic processing industry |

This paper represents qualitative exploratory study which is part of intensive study of RL in fashion industry. This exploratory study characterizes the current practices of the reverse supply chain channels in France and Germany. Actors and drivers as well as sorting, recycling and re-distribution have been identified for clothing recovery. In fact, sustainability in fashion industry has attracted both researchers and practitioners lately and it is one of the most complicated fields that require more studies and improvements in order to close the loop of the supply chain. The scarcity of scientific contributions (so far) has encouraged us to investigate and briefly write all aspects of product recovery in fashion industry with highlighting some research gaps for future studies. Framework and measurement of the sustainability of fashion industry, for instance, would be one of the future research studies for further contribution.

The textile recycling system itself seems to be simple, environment friendly and economic which could promote benefits to the fashion retailing which will contribute to Europe waste prevention legislation and target as well as to improve the circular economy. Re-wear, re-use, down-cycle and up-cycle will prevent disposal of apparel, linens, and footwear and will save water consumption and energy in making new clothes.

It is clear that there are many aspects affecting the processing and collection of textile waste. The process starts from governmental authority by putting a textile collection target and establishing authorized organizations to monitor and create flexible laws and conditions for businesses to practice collection, sorting, and recycling legally and smoothly. Also, reverse logistics network plays an important role because efficient design will promote a great cost reduction specially when dealing with locating and choosing the right sorting and recycling facilities. Eco TLC in France is spending 25% of the income in transporting the items and 65% in the sorting and recycling dealing with more than 40 sorting companies. On the other hand, the Wolfen sorting plant alone handles the same quantity of textile waste generating a great profit to the company as well as to the charities. Thus, re-

search and development and expertise in reverse logistics are important to develop cost-efficient system. Moreover, charities organizations are key actors in the textile waste system since the major collection is carried out through them. Today is not possible to progress and make more efficient way without the implementation of efficient RL design, good information system, and capable mechanical and automation systems. Trade-off between the actors will absolutely increase the efficiency of the RL system as well as generating profit. Since the infrastructure of transport and logistics system is important and it differs from area to area, they should be considered during designing and modeling a new RL system.

The RL network of the fashion retailing industry is complex and it differs from other RL networks such as for battery, carpet, and electronics because of the variety of collection schemes, recycling facilities and re-utilization channels as discussed in the case studies. Therefore, careful implementation is required to reduce the cost encountered in establishing and operating such RL system.

7 References

- American Apparel and Footwear Association, AAFA (2015) Accessed: 1 May 2015, available at: <https://www.wewear.org/industry-resources/we-wear-our-mission/>
- Beasley J, Georgeson R (2014) Advancing resource efficiency in Europe indicators and waste policy scenarios to deliver a resource efficient and sustainable Europe. Brussels: European Environmental Bureau. Available at: <http://www.eeb.org/EEB/?LinkServID=4E9BB68D-5056-B741-DBCCE36ABD15F02F>. Accessed 15 October 2014
- Caniato F, Caridi M, Crippa L, Moretto A (2012) "Environmental sustainability in fashion supply chains: An exploratory case based research", *International Journal of Production Economics*, Vol. 135, pp. 659-670
- Caro F, Martínez-de-Albéniz V (2014). "Fast Fashion: Business model overview and research opportunities", *Retail Supply Chain Management: Quantitative models and empirical studies*, 2nd Edition, Springer, New York, NY
- De Brito M, Carbone V, Blanquart CM (2008) "Towards a sustainable fashion retail supply chain in Europe: Organisation and performance", *International Journal of Production Economics*, Vol. 114, No. 2, pp. 534-553
- Govindan K, Soleimani H, Kannan D (2015) "Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future", *European Journal of Operational Research*, Vol. 240, No. 3, pp. 603-626
- La Fédération de la Maille & de la Lingerie. (2014) "On the textile recycling road", available at: http://www.la-federation.com/data/evenements_4c4be/fiche/5486/leaflet_recyclage_bf06f.pdf. Accessed 3 November 2014
- Mzikian, P. (2013). SOEX presentation at REINNOVA 2013. Waste management challenges within the framework of a green economy. 3rd International conference on innovative municipal waste management and treatment, REINNOVA, available at: <http://www.reinnova.es/test/wp-content/ponencias2013/03.02%20-%20P.Mzikian.pdf>. Accessed 10 December 2014.
- Palm D, Elander M, Watson D, Kiørboe N, Salmenpera H, Dahlbo H, Moliis K, Lyng K, Valente C, Gislason S, Tekie H, Rydberg T (2014) Toward a Nordic textile strategy: Collecting, sorting, reuse and recycling of textiles. Norden

Soex Group 2014.

<http://www.soexgroup.com/scripts/pages.php?ParentId=5&LanguageId=1&R=12>. Accessed 20 October 2014.

Tirad, L. (2013). The French EPR. Sustainability and Producer Responsibility in textiles. Mistra Future Fashion Symposium, available at: <http://www.mistrafuturefashion.com/en/media/news/Documents/Laurianne%20Tiard%2029%20May%202013.pdf>. Accessed 15 January 2015.

Toffel MW (2004) "Strategic Management of Product Recovery", California Management Review, Vol. 46, No. 2, pp. 120-141

Waste and Resource Action Programme, WRAP (2012) Valuing our clothes: The evidence base. Technical Report. Available at: <http://www.wrap.org.uk/sites/files/wrap/10.7.12%20VOC-%20FINAL.pdf>. Accessed 15 January 2015