REPORT

Improved waste management of textiles

Project 9 Environmentally improved recycling

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TOWARDS SUSTAINABLE WASTE MANAGEMENT

IVL Swedish Environmental Research Institute

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Organization	Report Summary
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Title and subtitle of the report
Improved waste management of textiles

Summary
In Sweden, we consume 15kg of textiles per capita and year. Of this roughly 8kg are incinerated and 3kg are reused by charity organisations. The remaining 4kg either accumulates (e.g. in a closet or wardrobe) or are handled through other means of waste management (e.g. recycling centres). This way of waste management is not optimal from an environmental point of view. The textile waste flows are small by weight but large by environmental impact. The production of virgin textiles give rise to about 15 kg of carbon dioxide per kg textile and uses large amount of water; energy and chemicals and poses a risk both for the environment and human health.

Policies and measures to reduce the consumption of virgin textile are needed. Hindrances for a more sustainable textile waste management are primarily economical: The environmental cost is not incorporated in the production of virgin textiles which is one of the reasons that they are cheap compared to reused and recycled textiles. They are also produced in low cost countries while collection for reuse by nature occurs in Sweden where labour is more expensive. Recycling of textiles is not due to economic reasons performed on a large scale in Sweden today.

There is a need to optimise the formal reuse of textiles from an environmental point of view, either with policy or voluntary agreements. Policies in this area must however be designed not to reduce informal reuse to achieve a higher environmental benefit. New cost efficient methods for textile recycling needs to be developed to enable high grade recycling of textiles not suitable for reuse. New textiles should be designed for reuse and/or recycling depending on their expected life time (aesthetic; technical) while conventional materials to a large extent needs to be replaced by more sustainable materials.

Keyword
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Foreword

The results presented in this report is a result of research done with support from the Swedish Environmental Protection Agency within the framework of the research programme ”Towards Sustainable Waste Management”. The result are a part of the project environmentally improved recycling which deals with hindrances and opportunities for environmentally improved recycling processes.

Summary

In Sweden, we consume 15kg of textiles per capita and year. Of this roughly 8kg are incinerated and 3kg are reused by charity organisations. The remaining 4kg either accumulates (e.g. in a closet or wardrobe) or are handled through other means of waste management where it is difficult to measure (e.g. recycling centres). This way of waste management is not optimal from an environmental point of view. The textile waste flows are small by weight but large by environmental impact. The production of virgin textiles give rise to about 15 kg of carbon dioxide per kg textile and uses large amount of water; energy and chemicals and poses a risk both for the environment and human health.

Policies and measures to reduce the consumption of virgin textile are needed. Hindrances for a more sustainable textile waste management are primarily economical: The environmental cost is not incorporated in the production of virgin textiles which is one of the reasons that they are cheap compared to reused and recycled textiles. Virgin textiles are produced in low cost countries while collection for reuse by nature occurs in Sweden where labour is more expensive. Large scale recycling of textiles is due to economic reasons not performed in Sweden today.

There is a need to optimise the formal reuse of textiles from an environmental point of view, either with policy or with voluntary agreements. Policies in this area must be designed not to reduce informal reuse to achieve a higher environmental benefit. New cost efficient methods for textile recycling needs to be developed to enable high grade recycling of textiles not suitable for reuse. New textiles should be designed for reuse and/or recycling depending on their expected life time (aesthetic; technical) while conventional materials to a large extent needs to be replaced by more sustainable materials.

Sammanfattning

I Sverige konsumeras ungefär 15 kg textil per person och år. Av dessa går ca 8 kg till förbränning och 3 kg återanvänds av välgörenhetsorganisationer. Resterande 4 kg ackumuleras (t ex i en garderob) eller genomgår annan avfallsbehandling där det är svårt att mäta mängderna (t ex via en återvinningscentral). Denna avfallsbehandling är inte optimal ur ett miljöperspektiv. Textilavfallsflödena är små viktmässigt men desto större miljömässigt. Produktion av ny textil ger upphov till ca 15 kg koldioxid per kg textil och förbrukar stora mängder vatten; energi och kemikalier och utgör en risk för såväl miljön som människors hälsa.

Styrmedel och åtgärder behövs för att minska konsumtionen av ny textil. Hindren för en mer hållbar avfallshantering av textil är främst ekonomiska. Miljökostnader är inte inkluderade i produktionen av ny textil vilket är en av orsakerna till att de är billiga i förhållande till återanvända och återvunna kläder. Ny textil produceras generellt i lågkostnadsländer medan insamling för återanvändning naturligtvis sker i Sverige där arbetskraft är betydligt dyrare. Storskalig återvinning sker av ekonomiska skäl inte i Sverige idag.

Det finns ett behov av att optimera den formella återanvändningen av textil ur ett miljöperspektiv, antingen med styrmedel eller med frivilliga åtaganden. Styrmedel inom detta område måste designas så att de inte riskerar att påverka den informella återanvändningen för att uppnå en ökad miljönytta. Nya kostnadseffektiva metoder för textilåtervinning behöver utvecklas för att möjliggöra en högnivå-återvinning av den textil som inte lämpar sig för återanvändning. Nya textilier bör dessutom designas för återanvändning och/eller återvinning beroende på deras förväntade livslängd (estetisk; teknisk) samtidigt som konventionella material till stor utsträckning behöver bytas ut mot mer hållbara material.

Contents

1 Introduction

1.1 The research programme

Towards Sustainable Waste Management is an interdisciplinary research programme dedicated to investigating policy instruments and strategic decisions that can contribute to developing waste management in a more sustainable direction. The primary target groups for the findings of Towards Sustainable Waste Management is the Swedish Environmental Protection Agency and other policymakers in the field of waste management at European, national, regional and local levels, recycling companies, waste management companies and R&D organisations in waste management.

The ten research projects in Towards Sustainable Waste Management are based on close cooperation and exchange of knowledge and results, see Figure 1. Each project adds important information and knowledge to the programme. These will be integrated in the project "Futureoriented synthesis", aiming at identifying decisions that contribute to the development of a more sustainable waste management system. In this way, the results of Towards Sustainable Waste Management will provide useful input to actual decision-making and strategy development in waste management and other related fields.

Figure 1 Connections between the ten subprojects of Towards Sustainable Waste Management research programme

The current report is a part of project 9 Environmentally Improved Recycling.

1.2 The project

The research project Environmentally Improved Recycling consists of four different case studies of which this is one.

The four case studies are:

Improved waste management of textiles

Improved recycling of plastics

Improved recycling of asphalt

Improved biological treatment and biogas production

The research project aims at identifying and assessing options for improving the environmental performance of recycling processes. We also aim at identifying actions and decisions that are required to facilitate these improvements. The purpose is to stimulate environmentally improved recycling.

However, in the beginning of this study it was found that little or no recycling of textiles occurs in Sweden. This called for a broader scope and this report therefore gives an overview of the entire waste management of textiles in Sweden. It aims at identifying obstacles for an environmentally improved waste management of textiles including not only recycling but also reuse.

2 Methodology

The methodology used in this project has mainly been a literature study where both scientific literature, such as scientific articles and reports, and popular science articles have been studied.

For a better understanding of the second hand (reuse) market of textiles, a survey was sent out to the ten of the largest second hand retailers in Sweden, seeTable 1. The survey investigated both data for collection, reuse, export and waste and more general questions on second hand. This was followed by interviews of some of their representatives. The interviews performed where semi-structured and consisted of a series of phone calls. The trade association Ideell Second Hand was also contacted.

Table 1 Second hand retailers contacted

No	Second hand retailer	Replied to survey	Interview	Data
1	Myrorna	Yes	Yes	2008
2	Emmaus Björkå	No	Yes	2008
3	Erikshjälpen	No		2008
4	Röda Korset	No		2008
5	Amnesty	No		No data
6	Humana Sverige	Yes		2009
7	PMU	No		2008
8	Stadsmissionen Stockholm	No		2008
9	Göteborgs kyrkliga stadsmission	No	Yes	Estimate 2008
10	Läkarmissionen	Yes		2008
11	Ideell Second Hand (trade association)	Yes		2008

As part of this project available recycling techniques have been studied as a master thesis by Zamani (2011). Zamani has evaluated the environmental performance of three different recycling techniques.

3 Delimitations

The project is limited to textiles consumed and discarded in Sweden. It does not cover all aspects of the environmental impacts of textiles and should be seen as an overview of the current knowledge in this area.

4 Consumption

The consumption of textiles in Sweden has risen notably in the last 10-15 years both according to the Swedish Society for Nature Conservation (SSNC 2010) and the Swedish Environmental Protection Agency (SEPA 2011). According to SEPA (2011) there has been a 40 % increase in textiles consumption between the years 2000 and 2009. The actual amount consumed however differs between the two where SSNC gives a consumption of 24 kg per person. This figure has been used frequently for the last five years and is based on an article in Råd & Rön (2003) written by Berit Carlsson. The original source for this figure is according to Carlsson and SSNC (2010) not known.

Consumption: 15 kg per capita and year

The new study from SEPA (2011) gives a consumption figure of about 15 kg per person and year which amounts to a total of about 130 000 tonnes annually in Sweden. The SEPA figure has been calculated using statistical data for domestic production, imports and exports and includes clothes and home textiles. It does not include industrial textiles and furniture textiles and the actual figure may therefore be somewhat higher.

5 Textile waste management

Depending on quality, condition and fashion accuracy there are four basic paths for used textiles.

Textiles can be:

Used again, formally or informally

Recycled, into new textile or other products

Used for energy, incineration with energy recovery

Landfilled, waste dumps

The EU waste directive from 2008 (2008/98/EC) presents a structure for preferred treatment of waste, where landfill (or other means of disposal) is the least preferable option and waste prevention is the most preferable option, see Figure 2. Re-use of textiles are at the highest and second highest level in the hierarchy. The other waste hierarchy steps are self-explanatory.

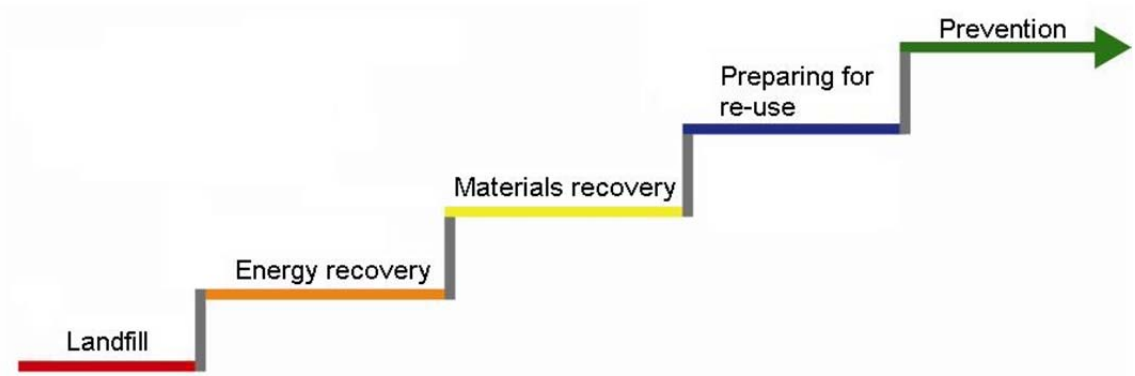


Figure 2 EU Waste hierarchy

5.1 Collection

The only nationwide collection of textiles today are as part of the sack- and bin-waste collection and as part of the energy recovery fraction at recycling centres. Many charity organisations organise collection of clothes and shoes both at recycling sites and recycling centres but the collection systems vary widely in different parts of Sweden (Myrorna 2010).

Currently no producer responsibility

Sweden has producer responsibility for packaging, tires, newsprint, WEEE, batteries, pharmaceuticals and radioactive products but not for textiles which might explain the lack of organised collection. This despite the fact that recycling and reuse of textiles has a far greater environmental benefit than for example recycling of newsprint and packaging (Sundqvist & Palm 2010, Morley et al 2006)

5.2 Reuse

Reuse of textiles is done in many different ways and forms and can be divided into three main types of reuse:

Formal reuse, e.g. second hand shops, store deposit-systems

Semi-formal reuse, e.g. Ebay; Blocket; Tradera

Informal reuse, e.g. children inherits clothes from siblings; friends sharing clothes.

The environmental benefit from reuse is substantial since it reduces production of new textile which, among other environmental effects, lowers the global warming potential by about 15 kg of CO2-equivalents per kg of textile (Ljunggren Söderman et al 2011, Sundqvist & Palm 2010).

5.2.1 Flows

The amount of clothes and home textiles that are informally reused is very hard to estimate. It can be considered common practice with baby clothing since these are rarely worn out before the baby has outgrown them. Parents use the same baby clothes for all their children and often also share baby clothes among friends.

Semi-formal reuse is a multimillion business for websites like Ebay and Blocket. According to Synovate (2011) the value of all sold products at Blocket during 2010 exceeded 200 billion SEK with clothes as the 8th most sold product.

Informal and semi-formal reuse prolongs the lifetime of clothes and textiles and thereby has an environmental benefit. The specific benefit is hard to estimate due to the nature of the reuse but it is important to keep in mind how these markets are affected by an increase or decrease of formal reuse. If formal reuse only replaces informal reuse there is no added environmental benefit.

Formal reuse 22 000 tonnes annually

Formal reuse is mainly done by charity organisations. The ten largest charity organisations collected almost 26 000 tonnes of clothes and shoes during 2008[1]. Roughly 22 000 tonnes was reused mostly in Africa and in Eastern Europe and to a smaller extent in Sweden (Ideell Second Hand 2010, Humana Sverige 2010, Myrorna 2010).

5.2.2 Environmental effects

Reuse is either part of prevention or preparations for reuse in the waste hierarchy. Preventing waste by reuse does not only reduce emissions from waste management but it also reduces production. The environmental benefit from reduced production is far greater than material recycling, energy recovery or biogas production (Ljunggren Söderman et al 2011, Morley et al 2009).

The environmental impact of textile production is not well documented. There are several studies covering energy use and a few that includes global warming but most studies only consider parts of the production and not the full life cycle (Madsen et al 2007). The data used in most studies are also often very rough estimates using rather poor process data (Oakdene Hollins 2010). A demonstrative example is that production data for polyester, which is the most common synthetic fibre, is not available in the Ecoinvent database or in PE Internationals databases, which are two of the most commonly used data providers for life cycle assessment (Ecoinvent Centre 2007, PE International 2006, PE International 2010).

Studies on the production of cotton rarely include the entire production chain and tend to focus on chemical use during farming and treatment and the acute risks this poses to farmers and workers in the textile industry (Madsen et al 2007, Engvall 2008).

One reason for this lack of knowledge can be that the production chain for textiles is incredibly complex with several production steps and different corporations involved. The report "Den blinda klädimporten"2 by Swedwatch (Engvall 2008) describes that even the retailers themselves have difficulties of controlling their own supply chain. Due to these mentioned problems with data availability and the scope of this project, only some key environmental issues are presented.

[1] Data from Humana Sverige is from 2009
[2] The blind import of clothing

15 kg CO_2-eq. per kg textile

Estimates of the global warming potential of textile productions are 16.9 kg CO2-equivalents per kg of 50% cotton and 50% polyester (Sundqvist & Palm 2010), 15 kg CO2-equivalents per kg of 50% cotton and 50% polyester (Ljunggren Söderman et al 2011) and 25 kg CO2-equivalents per kg of textiles (Persson, 2010). Compared to most other wastes the global warming potential from production of textiles can be considered rather high per unit weight (Sundqvist & Palm 2010).

For cotton, the most commonly used textile fibre, the two largest environmental issues are water and pesticide use (Kooistra et al 2006). Water use can be up to 29 m3 per kg of cotton which is a major problem since cotton production is often performed where water is scarce (DEPA 1997). Cultivation of cotton use about 11% of the world's pesticides but only uses 2.4% of all cultivated lands (Kooistra et al 2006). More on chemicals used in textiles (clothes) can be found in Olsson et al (2009).

For polyester, the second most commonly used textile fibre, the largest problem is that it requires huge amounts of energy for production. According to Westerdahl (2011) the primary energy needed for producing polyester fibres is more than three times higher than for producing cotton fibres.

Most textile production also leads to degraded soils and water resources due to emissions of toxic chemicals from for example dying processes. Again as an example Engvall (2008) describes the situation in Tirupu, India where many textile factories have limited or no water treatment of their waste water and those that do only operate their water treatment plants when inspections are expected. The water in Tirupu is contaminated to a level where the textile industry themselves cannot use it and import water from elsewhere.


(Photo: Swedwatch)

5.3 Recycling

There is currently no large scale recycling of textiles in Sweden, nor is there any major export for recycling of Swedish textiles (Stena 2010, Myrorna 2010, Ideell Second Hand 2010). The environmental effects from recycling of textiles depend on what kind of recycling being performed and what is replaced by the recycled textile.

5.3.1 Flows

Large scale industrial recycling of textiles occurred in Sweden until 1992 when Stena Gotthard closed down their recycling plant (Stena 2010). Since 1992 the only textile recycling has been the use of discarded rags as industrial wipes (Myrorna 2010).

In 2008-2009 only the charity Humana Sverige reported any textiles going to recycling (Humana Sverige 2010). This accounts for about 4% of the clothes collected by charities (Humana Sverige 2010, Ideell Second Hand 2010).

According to Stena (2010) there is no recycling of Swedish industrial textile waste.

5.3.2 Environmental impact

The environmental impact or benefit from recycling of textiles is hard to estimate. Few processes exist beyond lab scale and those that do are either low grade recycling or small scale niche recycling (Zamani 2011).

Existing large scale recycling techniques are sound insulation for cars; mattress filling; and industrial rags, which are used in for example the United Kingdom (Morley 2009). When used textiles replace virgin textiles in these applications the environmental benefit is likely close to that of reuse since the fabrics are basically only shredded before they are used again. If they however replace other materials, the environmental benefit may decrease substantially. If for example used as industrial rags, the used textile likely replaces tissue paper which has substantially less emissions during production and thereby reducing the environmental gain.

The waste strategy plan for England by Defra (2007) specified the general carbon dioxide saving of textile recycling to be 1-1.5 kg of CO2-eq. per kg textiles which is substantially lower than the saving from reuse of textiles.

Zamani (2011) has investigated the environmental performance of three different recycling options, namely separating cotton and polyester using N-methylmorpholine-N-oxide (NMMO); closed loop recycling of polyester and mechanical high grade recycling into new textile products.

NMMO Cotton / Polyester separation	The NMMO process investigated by Zamani has not been tested in large scale but involves separation of a mixed polyester and cotton fabric and therefore shows potential to be an important recycling technology. Further technical development and evaluation is however needed according to Zamani.
Closed loop Recycling	The closed loop recycling of polyester is today used by companies as Teijin and Patagonia. It only recycles polyester of a certain grade and is for now a niche market.
Remake Mechanical Recycling	The mechanical recycling is very small scale and consists of creative designers that use old clothes and textiles to produce smaller textile products such as wallets. This process can, by design, only be small scale. It has a rather poor recovery rate overall but is on the other hand very energy efficient.

Preliminary results from Zamani's study show that all these processes produce roughly 1 kg of CO2-eq. per kg textile but, since the recycled products are not comparable either between the three processes or between them and new products, a fair comparison cannot be made at this point.

5.4 Energy recovery and landfill

Incineration with energy recovery is besides charity collection the most common treatment of waste textiles in Sweden. As a waste for incineration, textiles are rather harmless but have some issues which leads to some textiles still being landfilled.

5.4.1 Flows

Textiles for incineration and landfill come from industry, retailers, charity organisations and consumers. The largest contribution comes from the bin and sack waste which amounts to an average of about 7.5kg[3] annually per capita (SEPA 2011). Another large flow is likely as combustible waste at recycling centres but this amount is today unknown (SEPA 2011).

In some cases the incinerator does not accept large amounts of for example industrial textiles which leads to them being landfilled instead. One reason for this is that long threads acts as a fuse from the incineration to the waste storage. This is however decreasing with added pre-treatment (cutting and shredding) (Stena 2010).

5.4.2 Environmental impact

The environmental impact of incineration with energy recovery of textile waste is of minor importance compared to the production of new textiles.

The carbon dioxide emissions from natural fibres can be considered as part of the natural flow of biogenic carbon dioxide emissions. Landfilling of cotton however emits about 0.2kg of CH4 (5kg of CO2-eq.). A pure polyester fibre produces about 2.3kg of fossil CO2 per kg textile when incinerated but very little when landfilled (Westerdahl 2011 based on Simonson et al 2000 and PE International 2006).

In the case of incineration with energy recovery, production of power and heat replace other energy sources which lowers the impact to some extent.

[3] Based on 57 pick analyses in 2008-2010. Values: Mean 7.9kg, median 7.3kg, min 2.4kg max 14.2kg

6 Hindrances and opportunities

Why textile waste is not handled in an environmentally preferred way is a complex issue. However the underlying hindrance appears to be economical (Stena 2010, Myrorna 2010). With a very low cost of production of new textiles all attempts to reduce consumption while increasing reuse and recycling becomes difficult. Environmental costs are not internalised in virgin production. It can also be hard to economically motivate producing quality textiles since the market price of textiles often is more dependent on brand, fashion and purchase cost rather than life cycle cost and quality (Kappahl 2004).

The listed hindrances and opportunities in this section are not absolute certainties. They are based on discussions with a variety of organisations including but not limited to those listed Table 2. Discussions and presentations from the industry innovation session hosted by Sustainable Fashion Academy (SFA 2010) and the event on the environmental impact of textiles hosted by the association Engineers for sustainability (IfM 2010) has also provided useful information for the analysis.

Table 2 Organisations contributing to the hindrance and opportunity analysis

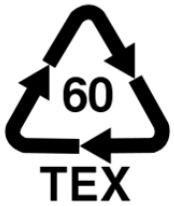
Organisation	Type	Reference
Myrorna	Charity organisation	Myrorna 2010
Stena Recycling	Recycling company	Stena 2010
The Swedish EPA	Governmental	SEPA 2011b
Oakdene Hollins	Research and consulting company	Oakdene Hollins 2010

Hindrances and opportunities described are sorted as institutional; legal; social; economical and technical. Some are of them are of course dependant on a number of different barriers.

6.1 Consumption

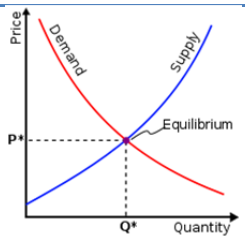
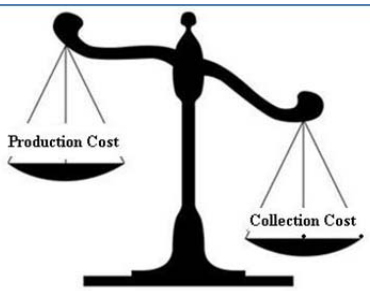
The focus when discussing consumption of textiles often tends to be on high end consumers, buying top of the line fast fashion. I this case clothes are often discarded due to not being fashionable anymore. This is of course relevant but one must not forget the consumer group that is not that fashion conscious or is more into classic fashion. In the latter case clothes are more likely to be discarded due to having some defect (e.g. tears; discolorations; faded; missing a button). There is also a large range of purchased quality e.g. from a cheap commercial T-shirt to an expensive quality brand T-shirt.

A field study by Oakdene Hollins showed that in poorer areas the amount of textiles in the waste stream was larger than in wealthier areas (Oakdene Hollins 2010). This could partly be explained by lower quality clothing. A higher quality can possibly increase the life length of clothing. Increased quality has both hindrances and opportunities as seen in the table below where a number of hindrances and opportunities for sustainable consumption are listed.

Hindrances	
Institutional: Retail price is not closely related to the quality of the product. The retail price of a clothing item is dependent on many factors besides quality. This makes it difficult for the average buyer to know whether a high price is motivated by increased quality or other factors. In this case the bought item tends to be the cheaper alternative simply in order to reduce economic risk. One does not run the risk of paying much for a clothing item that is of low quality.	*"It may not last long, but it was not that expensive anyway."*
	**Institutional: Fashion changes quickly thus making fully functioning clothes worthless.** A clothing item that is extremely fashionable this year may be "totally out of style" the next year or even quicker than that. This creates a gap between aesthetic and technical lifetime.
Opportunities	
Institutional: Quality labelling of textiles. An independent label giving for example a minimum number of washes with preserved function and appearance might encourage buyers to pay for quality.	
	**Technical: Produce for recycling.** Clothing that is produced for fast fashion should be designed for recycling rather than reuse.

6.2 Reuse

Reuse is today mainly limited by economic conditions with low cost of virgin textile and fast changing fashion. There are however opportunities in that second hand may be a fashion in itself and that the informal second hand market is to a large extent working without any specific policy instruments.

Hindrances	
Technical: The quality of new textiles is not high enough to enable a second hand use. Much of the textiles collected by charity organisations are not of a sufficient quality to be sold and reused on the Swedish market. This is to some extent solved by exports to less demanding markets outside of Sweden but also leads to incineration.	
	**Social, institutional: Fast fashion makes "out of style" clothing hard to sell second hand.** Some clothing is fashion sensitive, which when fashion changes creates a large supply of this type of clothing when at the same time there is little or no demand.
Social: Reused clothes are to some extent considered filthy. Although second hand clothing has become a fashion in itself to some extent in recent years, there is still a widespread opinion that second hand clothing are filthy and for those who cannot afford new clothing. A not uncommon comment is that it "smells old" in second hand stores.	
	**Economical: Price of second hand textiles is not competitive compared to new textiles.** Handling costs (collection, sorting and selling) of reused textiles in Sweden are high compared to material and productions costs in textile producing countries such as India and China which makes second hand clothes comparably expensive.
Economical: Charities collection of textiles is not aimed at maximising reuse. Most, if not all charity organisations, optimise their business to maximise profit for their charity work rather than for maximum reuse and environmental benefit.[4]	

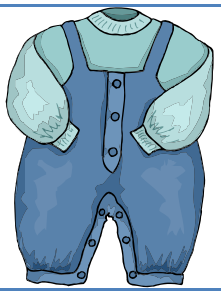
[4] This does not mean that there is no environmental benefit. It only implies that it in some cases can be higher.

Legal, institutional: Lack of national coherence in collection systems. Since collection is done on a voluntary basis and not necessarily in cooperation with normal waste management (e.g. municipal) it can be confusing for the average person to know how and where to discard used clothing. The charity organisations collection systems vary which is sometimes used by rogue collectors which then i turn damages the common confidence of the system.

Economical, social: The labour cost of repairing a garment is often higher than the purchase of a new garment. Service costs in Sweden are expensive compared to production costs i textile producing countries. The extreme case is when it is actually cheaper to buy a new garment rather than to have it professionally cleaned.

Opportunities

Institutional, economical: Provide export opportunities for organisations lacking this option today. Better cooperation between textile collectors could lead to increased exports of lower quality textiles and thereby increased reuse. The organisation Human Bridge, which is a co-operation between Läkarmissionen and Erikshjälpen, provides a useful example.



Social: There is an underlying ambivalence to the filthiness of reused clothes since baby or children's clothes are more likely to be considered free-of-toxins. Second hand retailer should be able to use the fact that when parents by second hand clothing for their babies, it is considered free of toxic substances since it has been washed several times.

Legal: Create a producer responsibility. A producer responsibility for textiles needs to be somewhat different than for other materials. Both targets for reuse and for recycling needs to be set not to run the risk of sending reusable textiles to recycling with the associated environmental losses.

Legal, institutional: Make it mandatory for municipalities to provide collection for reuse. Collection for reuse of textiles could be provided at all recycling centres[5] or recycling stations[6]. Certify collectors who collect at these sites to ensure reuse.

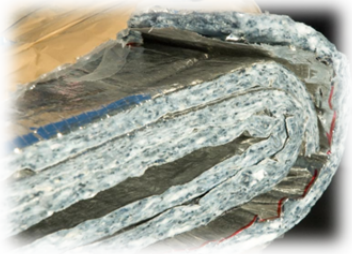
Legal: Reuse certificates
Reuse certificates can be used to set a lower limit on textile reuse without radically changing market conditions for either charities or retailers. The general principle can as the renewable energy certificates used in Sweden today. It does however need to be extensively investigated on what certificates can and should be based on (kg, pieces, SEK, etc.).

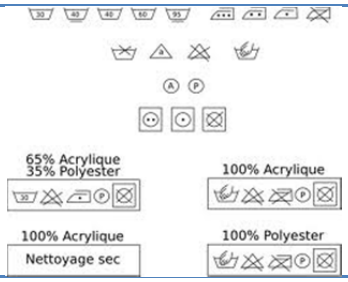
6.3 Recycling

Recycling is a non-existing market which is due to economical, technical and institutional hindrances. Textiles are today a complex material which makes it hard to recycle but different niche markets may provide a basis for an increased recycling. It must however be approached with care since it if implemented improperly may replace reuse which is not recommended from an environmental point of view.

Hindrances

Economical: Current recycling technology produce low grade products with a low value. Current recycling technologies are rather crude and produce low value products. Due to cheap virgin production there is little incitement to try to compete with high end products.





Technical, economical: Textile waste is not a homogenous material. Textiles are not one material but an infinite mix of different fibres not only in different garments but also in the same fabric. The fibres and fabrics have of course different colours and are hard to dye if the exact composition is not known.

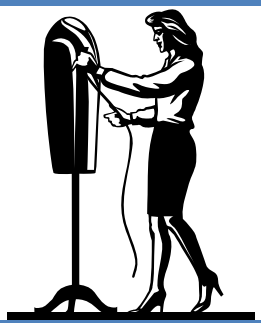
[5] Swe: Återvinningscentraler
[6] Swe: återvinningsstationer

Technical: Textiles are not designed for recycling. It is hard to separate textiles in automated processes since a fabric often include several materials. If sorting also needs to be for reuse it becomes even more difficult since an aesthetic judgement is called for.

Economical: Scale. The amount of textiles for recycling in Sweden is too small for an efficient recycling. Therefore recycling must be done either abroad or partly with imported textiles.

Opportunities

Technical, legal: Design both for reuse and recycling. Design of new textiles can be differentiated depending on what the textile should be used for. If it is a short lived garment either due to fashion or its inherent nature it should preferably be made of a standardised material which is suitable for recycling. If it is a high quality garment which will be used for many years a more complex fabric may be used.



7 Conclusions

Textile waste is not a large waste stream by weight or volume but has a significant environmental impact connected to the production of textiles. When this project started very little was known both about actual consumption and of the connected environmental impact. Since then, a number of studies, workshops and seminars have been performed and the knowledge in this area is increasing rapidly.

15

In Sweden we consume on average about 15 kg of textiles per person and year. Of this, about eight kg are incinerated and three kg are reused while basically nothing is recycled. Four kilograms are unaccounted for and one can only speculate where they end up. Larger houses with more closets is one explanation; incineration through recycling centres is another.

There is a definite need to move up the waste hierarchy for textiles, maybe not primarily because of the contribution to global warming and energy use but because of the inherent lack of sustainability over the entire production chain. Textile production shows a significant environmental impact regardless of environmental impact category (global warming, acidification, eutrophication, toxicity, etc.) due to a heavy use of pesticides; herbicides; chemicals; salt; water and energy. We need to reduce, reuse and recycle to a larger extent to reduce the impact of all these factors. We also need to move to more sustainable materials for textiles and perhaps replace some of the now common fabrics.

The overall hindrance for moving into a more sustainable textile use is not surprisingly economical. New textiles are very cheap and as long as this is the case the consumer will likely prefer new textiles compared to reused ones. Since it is difficult for Sweden to influence the production cost we need to work on levelling the difference in price between virgin and reused/recycled textiles with some kind of policy on our own market. What kind of policies that should preferably be used is a subject for further studies.

Recycling of textiles is probably a question that needs to be addressed on a larger scale than Sweden. Industrial recycling needs to be large scale and the textile flows in Sweden are according to the recycling companies too small for an efficient recycling process. More research is needed to find optimal recycling methods.

8 Recommendations

Improved reuse	There is a need for policies or voluntary agreements to make reused clothes more competitive compared to new clothes. The current system for reuse is purely market based and is not optimised from an environmental point of view. A policy must be carefully designed not to reduce informal reuse. The work on policies in Towards Sustainable Waste Management can be used as a basis for future studies on textiles.
Improved recycling	Sweden has no large scale recycling. To be able to run efficient recycling that can compete with virgin material prices, the recycling needs to be highly automated with large material flows. This is hardly possible on the Swedish market alone and one must therefore look at recycling at a larger market. Research on new recycling techniques are needed both in the area of separation and production based on recycled fibres. Focus of recycling research should be on high grade recycling (preferably closed loop).
New materials	Some of the materials used in textiles today (e.g. cotton) are not sustainable even with a rather high grade of reuse and recycling and new materials therefore need to be developed.
Design for environment	To reduce the environmental impact from textiles, the design of clothes need not only be focused on fashion but also on the life cycle of the clothing item. A short lived clothing item (due to fashion, inherent properties or other) needs to be designed with recycling in mind while a long lived clothing item should be designed to last long, perhaps with some parts interchangeable to enable easy repair and to make it suitable for the second hand market.

9 References

2008/98/EC (2008) DIRECTIVE 2008/98/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 November 2008 on waste and repealing certain Directives

Madsen, Jacob, Hartlin, Bryan, Perumalpillai, Shahila, Selby, Sarah and Aumônier, Simon. (2007). *Mapping of Evidence on Sustainable Development Impacts that Occur in Life Cycles of Clothing: A Report to the Department for Environment, Food and Rural Affairs.* Environmental Resources Management (ERM) Ltd. Defra, London.

DEFRA (2007) *Waste strategy for England 2007*. Department for Environment, Food and Rural Affairs. http://www.defra.gov.uk

DEPA (1997) *Environmental Assessment of Textiles.* Environmental Project No. 369. Danish Environmental Protection Agency

Ecoinvent Centre (2007) *Ecoinvent data v.2.0*. Ecoinvent reports No. 1–25, Swiss Centre for Life Cycle Inventories, Dübendorf

Engvall, M. (2008). *Den blinda klädimporten.* Report no 21. Swedwatch and Swedish Society for Nature Conservation

Humana Sverige (2010) Personal communication with Trond Narvestad,. Humana Sverige 2010-09-25

Ideell Second Hand (2010) *Statistik ISH 2008*. http://www.secondhand.se

IfM (2010). Textiliers miljöpåverkan och produktionsvillkor. Ingenjörer för Miljön. Göteborg 2010-10-06

Kappahl (2004). Årsredovisning 2004.

Kooistra, K.J., Pyburn, R., Termorshuizen,A.J. 2006. *The sustainability of cotton. Consequences for man and environment*, Science Shop Wageningen University & Research Centre. Report 223. ISBN: 90-6754-90-8585-000-2.

Ljunggren Söderman, M., Palm, D. Rydberg, T. (2011) *Förebygga avfall med kretsloppsparker.* Report B1958. IVL Swedish Environmental Research Institute Ltd, Göteborg

Morley, N.J., Bartlett, C., McGill I. (2009). *Maximising Reuse and Recycling of UK Clothing and Textiles:* A report to the Department for Environment, Food and Rural Affairs. Oakdene Hollins Ltd

Morley, N., Slater, S., Russel, S., Tipper, M., Ward, G. D. 2006. *Recycling of low grade clothing waste.* Oakdene Hollins Ltd, Salvation Army Trading Company Ltd, Nonwovens Innovation and Research Institute Ltd.

Myrorna (2010) Personal communication with Emma Enebog, Sustainability strategist. Myrorna 2010-05-03

Oakdene Hollins (2010). Personal communication with Nick Morley, Oakdene Hollins Ltd 2010-08-19

Olsson, E., Posner, S., Roos, S., Wilson, K. (2009). *Kartläggning av kemikalieanvändning i kläder.* Uppdragsrapport 09/52 Swerea IVF, Mölndal

PE International (2006), *GaBi Professional Databases 2006*.

PE International (2010), Personal communication with David Drysdale, PE International 2010-08-23

Persson, T 2010. *Samhällsnyttan av Ideell Second Hand.* Ideell Second Hand

SEPA (2011). *Kartläggning av mängder och flöden av textilavfall.* (Mapping of amount and flows of textile waste). Swedish Environmental Protection Agency . Stockholm

SEPA (2011b). Naturvårdsverkets dialogforum. Swedish Environmental Protection Agency and research programme Towards Sustainable Waste Management. Stockholm 2011-02-09 – 2011-02-10

SFA (2010). Industry Innovation Session: Den gömda skatten: Ökad återanvändning och återvinning – En miljövinst för textilbranschen. The sustainable fashion academy. Stockholm 2010-03-30

Simonson, M; Blomqvist, P; Boldizar, A; Möller, K; Rosell, L; Tullin, C; Stripple, H; Sundqvist, J-O (2000). *Fire-LCA Model: TV Case Study.* SP Report 2000:13 ISBN: 91-7848-811-7, Borås

SSNC (2010) Personal communication with Jessica Andreason. Swedish Society for Nature Conservation 2010-08-10

Stena (2010). Personal communication with Christian Cronwall, Stena Recycling 2010-04-12 & 2010-04-26

Sundqvist, J-O., Palm, D. (2010) *Miljöpåverkan från avfall – Underlag för avfallsprevention och förbättrad avfallshantering.* Report B1930. IVL Swedish Environmental Research Institute Ltd

Synovate (2011). http://www.blocket.se/omblocket.htm?ca=15 accessed 2011-02-18

Westerdahl (2011). Personal communication with Jenny Westerdahl, IVL Swedish Environmental Research Institute 2011-03-23

Zamani, B. (2011). *Carbon footprint of textile recycling* (working title). Master thesis in Innovative and sustainable chemical engineering. Chalmers University of Technology, Göteborg

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