TEXTILES: FROM WASTE TO RESOURCES IN DENMARK

An Interactive Qualifying Project Final Report

Submitted to

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Abstract

This project, organized by the Danish Waste Association (Dansk Affaldsforening), will discuss discarded textiles as a valuable resource for organizations in Denmark. We strived to reduce the environmental footprint of textiles by increasing the collection and subsequent reuse, and where not possible, recycling of used textiles through optimizing textile collection methods and cooperation between stakeholders of humanitarian organizations and municipalities. We will assess: 1) current reuse and recycling systems, 2) compare strategies among different organizations, and 3) facilitate cooperation through workshops.

Executive Summary

Textiles are used in numerous common items such as clothing, shoes, furniture, cars, and more. The production of these textiles consumes large quantities of resources and generates a lot of pollutants. Furthermore, textile consumption has risen and thus, the environmental burden is increasing (Danish Government 2015). In order to minimize the environmental footprint of textiles, Denmark has been collecting textiles for reuse and recycling as well as launching initiatives on textile waste prevention and management. However, with over fifty percent of textiles still entering the waste stream, further research and solutions need to be developed in order to increase textile sustainability within Denmark.

In order to reduce the environmental burdens of textiles, the Danish waste sector is looking to increase textile collection for reuse and recycling. The goal of this project was to assist the Danish Waste Association's efforts to reduce the environmental footprint of textiles by increasing the collection and subsequent reuse, and where not possible, recycling of used textiles through optimizing textile collection methods and cooperation between stakeholders of humanitarian organizations and municipalities. We accomplished this goal via the following objectives:

1. Assess the current reuse and recycling systems in place
2. Identify similarities and differences in approaches to reuse and recycling of textiles among various organizations in Denmark
3. Facilitate stakeholder cooperation via a workshop

We accomplished the first two objectives by conducting site visits and interviews with representatives of stakeholders. By visiting the facilities and conducting interviews, we were able to identify areas of reuse and recycling that could be improved. To further understand the current systems, we did content analysis of previous studies. From the collected data, we constructed a cost benefit analysis and compiled a presentation which was used in a workshop in order to unify stakeholders and develop solutions to turn end of life textiles into resources.

The workshop brought together members from all aspects of the management system, providing a unique opportunity for cooperation. The responses to the discussion topics emphasized overlaps which made it possible to develop five different areas for analysis. The areas included the analysis of VAT-free status, the analysis of sharing benefits, the analysis of educating the consumer, the analysis of providing options to the consumer, and the analysis of convenience for the citizen.

After analyzing our findings we recommend the Danish Waste Association consider the following:

Convenience for the citizen

- Implement different strategies for rural and urban collection
- Provide door-to-door collection where appropriate
- Allow citizen to decide final destination of their used textiles

Consumer Behavior

- Survey on consumption and donating habits

Education

- Develop and provide educational pamphlets
- Develop and provide a comprehensive collection site map

Legislation

- Consider making changes to legislation
    - Incineration fees for humanitarian organizations
    - Protecting VAT-free status for humanitarian organizations

Cooperation

- Future workshops with the purpose of maintaining communication

These recommendations will prove useful for the Danish Waste Association.

Authorship and Acknowledgements

Christine Carbone, Charles Hill, Caroline Meyer, and Leah Morales all contributed to the writing of this report in equal proportion. All sections were collaboratively written and revised in order to ensure accurate representation of data and clarity in writing.

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Table of Contents

Table of Figures

Table of Tables

Introduction

Increasing textile consumption is leading to rising environmental burdens. Between 1990 and 2004, the global demand for textiles increased by 20 million tons (Farrant, Olsen and Wangel 2010). The production of textiles to reach these demands has contributed to increasing CO_2 emissions, water usage, and toxic chemical use. To offset rising demands for textiles, alternative methods both in the production and in the provision of access to textiles for consumers must be considered in an effort to decrease the environmental impact of textiles.

Alternative strategies to reduce the damaging impact of textile production are being considered. Through efforts to optimize reuse and recycling of textiles, Denmark is currently collecting 46% of used textiles for reuse and recycling via the efforts of humanitarian organizations and private collectors. Although Denmark already collects a significant fraction of textiles, much of the textiles that are discarded in bulk and municipal waste are suitable for reuse and recycling (Watson et al 2015). Current estimates state that approximately 64% of textiles discarded as waste are suitable for reuse (Anders Damgaard, personal communication, March 31, 2016). Additionally, 11-21% of discarded textiles which cannot be reused are suitable for recycling (Anders Damgaard, personal communication, March 31, 2016). Thus, collection rates could be increased with increased cooperation among municipalities, humanitarian organizations, and private collectors.

There is currently little cooperation between municipalities and humanitarian organizations. While collection of textiles is organized well within organizations, collection is not well coordinated among the various organizations of the reuse and recycling industry. Since waste collection methods vary among municipalities, cooperation among all stakeholders is vital.

With increased cooperation among stakeholders leading to increased collection, more textiles can be salvaged for reuse and subsequent recycling. Reuse is preferred to recycling as this method provides a larger environmental benefit, even if the substitution factor—replacing a new textile with one that is reused—is low (Schmidt et al 2016). Since reuse of textiles is much more environmentally favorable than recycling, stakeholders should cooperate in order to collect the maximum amount of reusable textiles.

This project assisted the Danish Waste Association's efforts to reduce the environmental footprint of textiles by increasing the collection and subsequent reuse, and where not possible, recycling of used textiles through optimizing textile collection methods and cooperation between stakeholders of humanitarian organizations and municipalities. To accomplish this mission, we assessed current textile reuse and recycling systems, identified similarities and differences in approaches to recycling and reusing textiles among various organizations within Denmark, and facilitated stakeholder cooperation via a workshop on methods to optimize the reuse and recycling of textiles.

Background

Increased reuse and recycling of textiles are an integral part of Denmark's textile waste management goal. Although initiatives and proposals for increased reuse and recycling methods have come to fruition in recent years, there is still a large fraction of textiles that could and need to be collected. In this chapter, we investigate the various destinations in the life of textiles in Denmark.

Textiles are defined as any type of cloth or woven fabric. While textiles include a range of products from apparel to fabric in vehicles, this project deals only with clothing and light home textiles, which account for 65% of textiles in the Nordic region (2013a). Focus is placed on textiles constructed out of fabrics that are calculated to be the most common: cotton (57%), synthetics (34%), wool (4%), and other (4%) (Schmidt et al, 2016). After analyzing textile flow, we assess Danish collection, reuse, recycling, and incineration practices. We also display the issues the Danish system is currently facing in each of these areas. Finally, we discuss textile collection, reuse and recycling practices from other countries to demonstrate possibilities for the Danish textile economy.

Hazardous Life Cycle of Textiles

Consumer demand continues to drive the steady production of textiles around the world, as shown by the global demand for textiles increasing by 20 million tons between 1990 and 2004 (Farrant, Olsen and Wangel 2010). The annual supply of clothes and home textiles in Denmark is 89,034 tons (2013a). As a point of comparison, greenhouse gas (GHG) emissions caused by the average yearly textile consumption of one person in Denmark is equivalent to pollution generated by traveling 2,143 km by car (Nielsen et al. 2014). Furthermore, textile consumption is equivalent to 55% of the average household's CO_2 emission from electricity use (Nielsen et al. 2014). Finally, water needed for textile production is 1.8 times higher than the annual consumption of the average household (Nielsen et al. 2014). As shown by these comparisons, efforts need to be made to address the environmental impact made by textiles.

All products have an environmental impact. Given the significant amount of textiles produced annually, it is imperative that ways to reuse, recycle, properly dispose of, or even reduce production need consideration. The life cycle of textiles includes production, transport, use, and end-of-life. Production has the largest environmental impact and covers all procedures from material extraction to assembly and design finishes (Nielsen et al. 2014). Transport covers all transportation in the lifecycle of the textile. Use includes washing of the textile; the product is estimated to have a lifetime of four years and to be washed 20 times a year (Nielsen et al. 2014). A textile enters the end of life stage when it is discarded by its first user, although textiles can also become waste without ever having been worn. Figure 1 is a visualization of this journey. In order for a product to be considered eco-friendly, individuals must make, use, and dispose of products in an environmentally conscious manner (Muthu 2015).

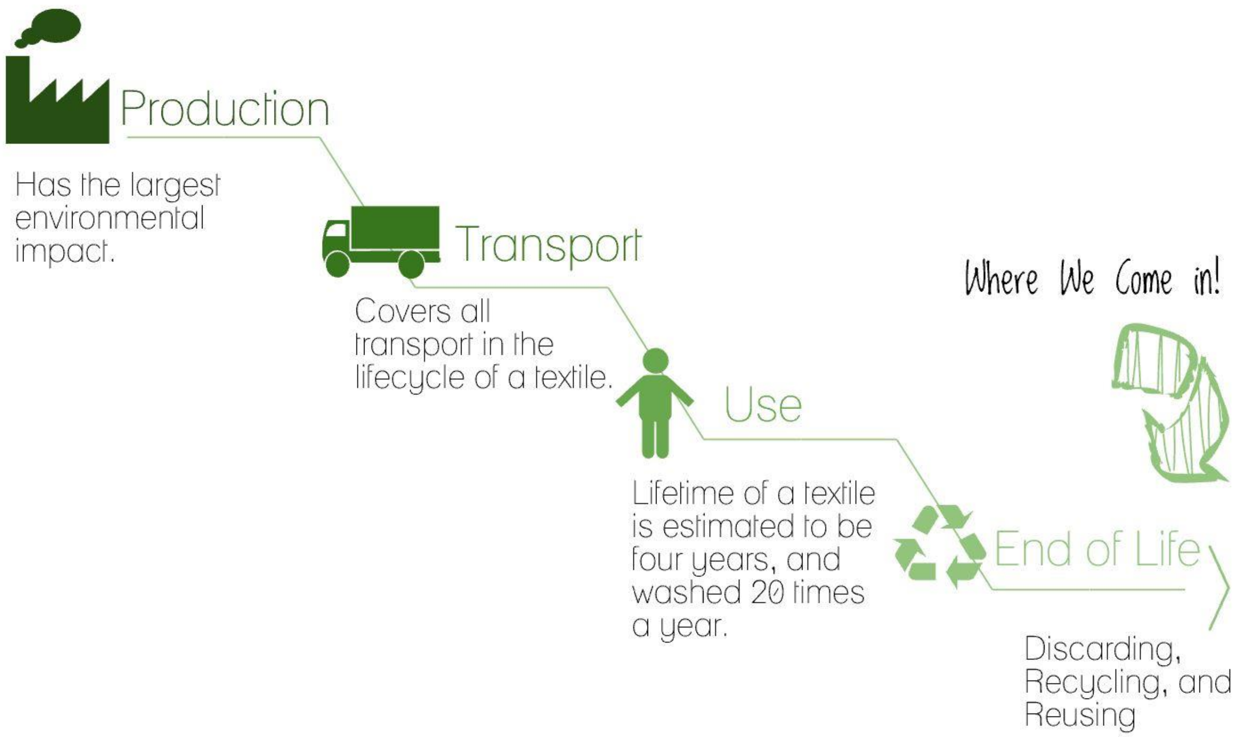

Figure 1: Visualization of textile life cycle, adapted from Nielson 2014.

Production

In the life cycle of textiles, production uses the greatest amount of water and releases the most CO_2 gases (Nielsen et al. 2014). Campaigns to reduce environmental damage have determined that limiting the amount of textiles produced will have the greatest positive effect (Klepp and Paulander 2014). A hierarchy has been established in accordance to the appeal of waste management options. As shown by Figure 2 below, waste prevention is the most efficient option while landfilling is the least efficient with the highest environmental impact. Reducing textile production will not only limit the use of water, energy, and toxic chemicals, but will also reduce carbon emission related to transportation.

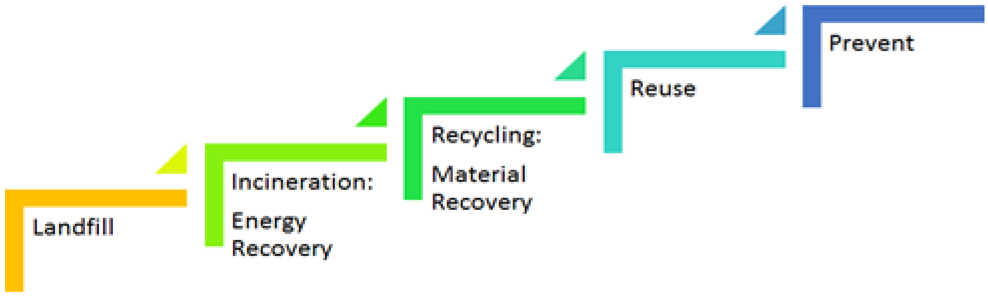

Figure 2: Waste management hierarchy

In addition to CO_2 emission and water consumption, toxic chemicals are used during textile production. For natural materials such as cotton, processing requires substantial amounts of chemical fertilizers and pesticides that pollute the soil (Challa 2014). Additionally, viscose is made from wood pulp, which is treated with hazardous chemicals including caustic soda and sulfuric acid (Challa 2014). Synthetic materials, such as nylon and polyester are made from petrochemicals and are non-biodegradable (Challa 2014). Each of these materials must also be bleached, dyed, and finished, which require large amounts of chemicals.

End of life

Following production, textiles are transported, sold, and used. Eventually, textiles enter the end of life phase where they are either separately collected and reused or recycled, or discarded in mixed household waste. In the case of Denmark the primary treatment for mixed household waste is incineration with energy recovery. Reuse means that the textile product is used again for its original function while recycling entails recovery of the materials in the product for input to new production (of textiles or other products). Reuse can directly offset the production of new textiles, thereby reducing the impact from production. The caveat that reuse presents is the difficulty in quantifying the substitution factor. That is to say, there is only limited data on the extent to which the reuse of a product will prevent the purchase of a new product of the same kind. Farrant (2008) carried out a limited questionnaire survey of people purchasing second-hand items Estonia, Sweden and Denmark. By scaling up results to country demographics the study estimated displacement rates of 60% in Sweden/Denmark and 75% in Estonia.

Reuse is preferred to recycling as this method provides a larger environmental benefit even with low substitution factors (Schmidt et al 2016). A substitution factor is the replacement of a new textile with a reusable one instead. For example, a substitution factor of 1 means that the purchase of a reusable textile replaced a new textile, while a factor of 0.2 means that the purchase of a reusable textile replaced 20% of a new textile. The impacts from different treatment routes can be seen in Figure 3; it is clearly demonstrated that reuse has significant environmental benefits compared to chemical recycling, even with a substitution factor lower than 0.33. The study estimates that the substitution factor could possibly be less than 0.1 before the reduced energy consumption is roughly equivalent for reuse and recycling (Schmidt, 2016). Thus optimal options for textiles are in line with the waste hierarchy; reuse before recycling, recycling before incineration with energy recovery.

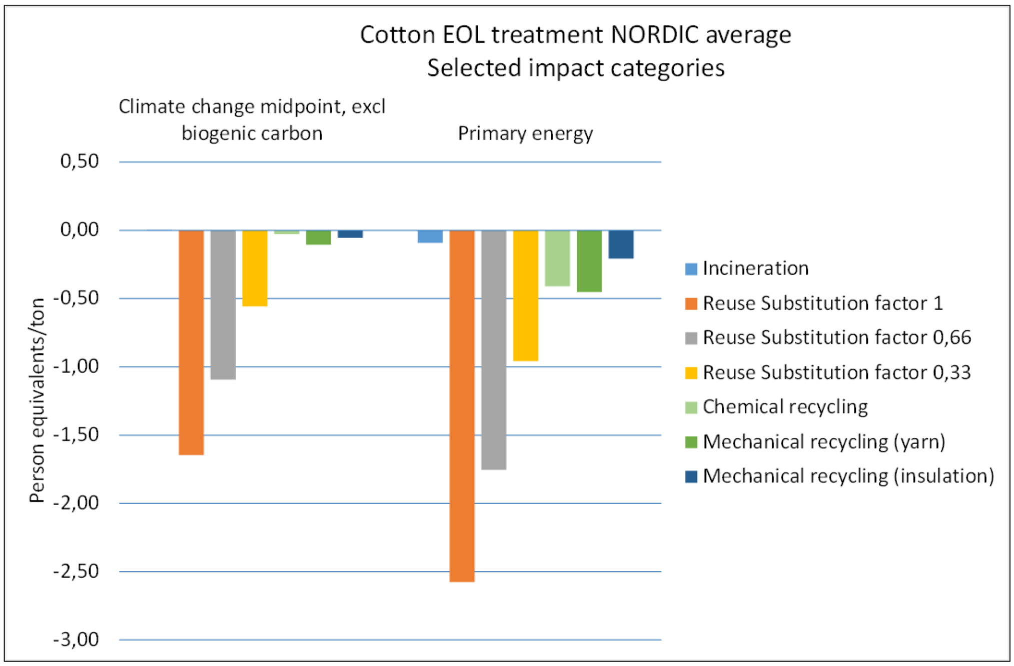

Figure 3: Impacts and benefits from different treatment routes for discarded average textile mix in the Nordic countries (Schmidt et al, 2016).

Moreover, far from all discarded textiles are suitable for reuse. A significant share has too much wear and tear to be reused. To optimize environmental benefits, textiles which are not suitable for reuse should be separately collected and recycled as far as possible. The overall goal of treatment of textiles is illustrated below in Figure 4; increase the active lifetime of textiles via passing through consecutive users, and when no longer fit for use, material recovery.

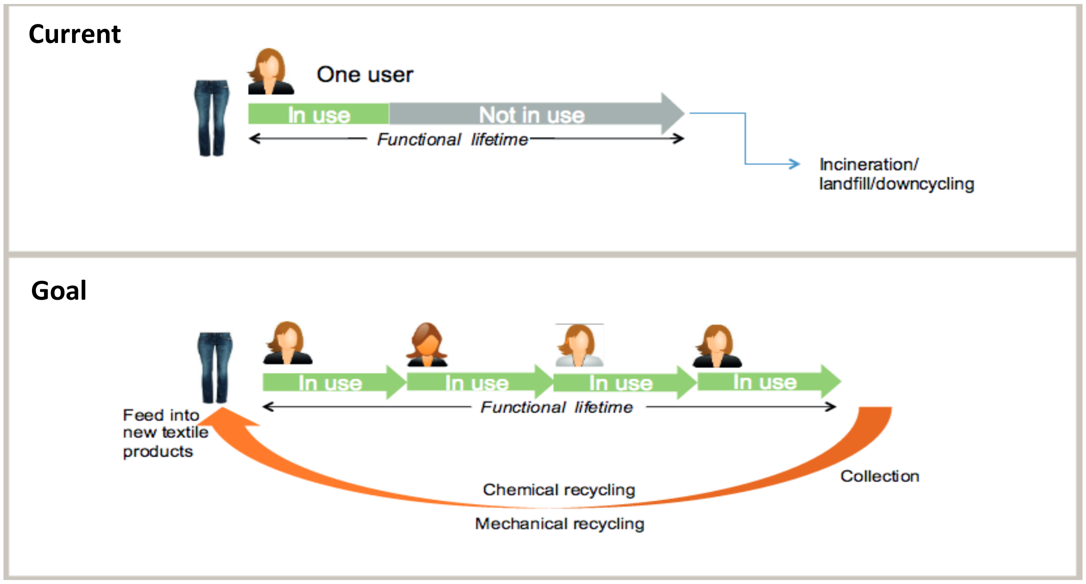

Figure 4: Overall goal for treatment of textiles to lower environmental burden (Watson, 2014).

In order to effectively increase textile sustainability, the current flow for the end-of-life stage of textiles must be assessed. In Denmark, there are currently five main destinations for textiles in this stage: domestic reuse, domestic recycling, exporting for reuse and recycling, landfilling (though almost non-existent in Denmark)(Tojo et al 2012), and incineration. Figure 4 below maps the flow of discarded textiles to these various destinations. Each of these outcomes will be discussed to fully understand this stage in the life of a textile.

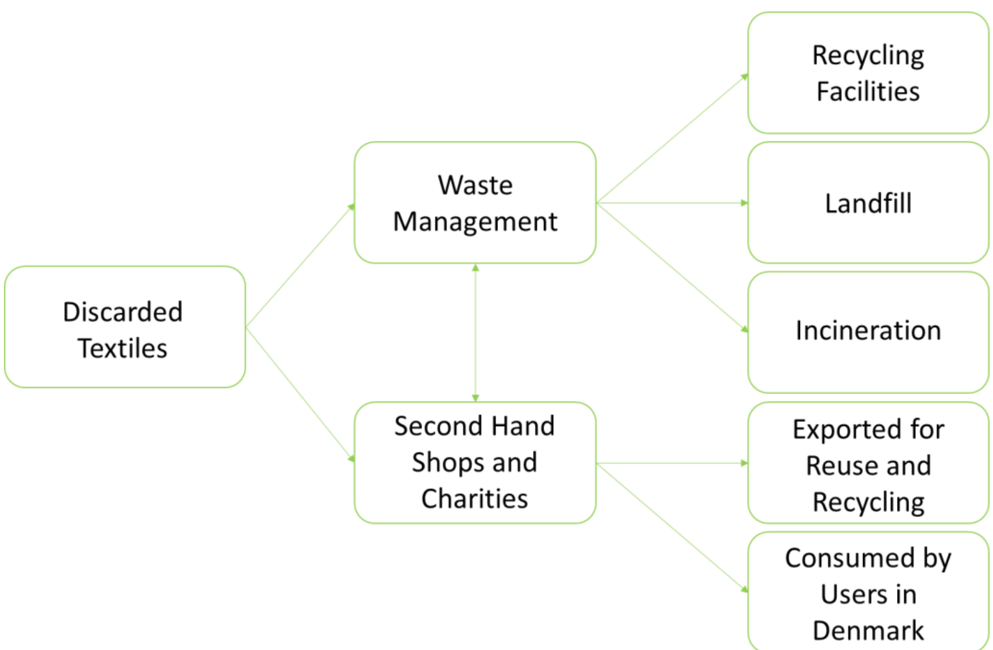

Figure 5: Textile flows in end-of-life stage in Denmark

When a textile is landfilled or incinerated, the material cannot be used again and the life of that textile is ended. To increase textile sustainability, a country must decrease consumption of new textiles by increasing the lifespan of textiles that are already in the cycle. As a preliminary step, the Nordic Council of Ministers commissioned a study to estimate the textile flow in Denmark in 2010. This study contains a flowchart that illustrates the flow of textiles; this chart includes estimates (in tons) of textiles being imported, exported, used, and at waste management facilities (see Figure 6) (Tojo et al. 2012). The flowchart draws attention to the major gap in Denmark's current system for textile sustainability— too many textiles are exiting the cycle and entering ordinary waste management.

This gap has a number of causes. Firstly, charities and other collectors have until very recently only accepted textiles that are directly suitable for reuse since there is currently little profit in the non-reusable fraction. This is exacerbated by the fact that consumers find it difficult to evaluate what is reusable. Secondly, some consumers aren't motivated enough to donate their textiles to charities and need to be activated in other ways via more convenient solutions.

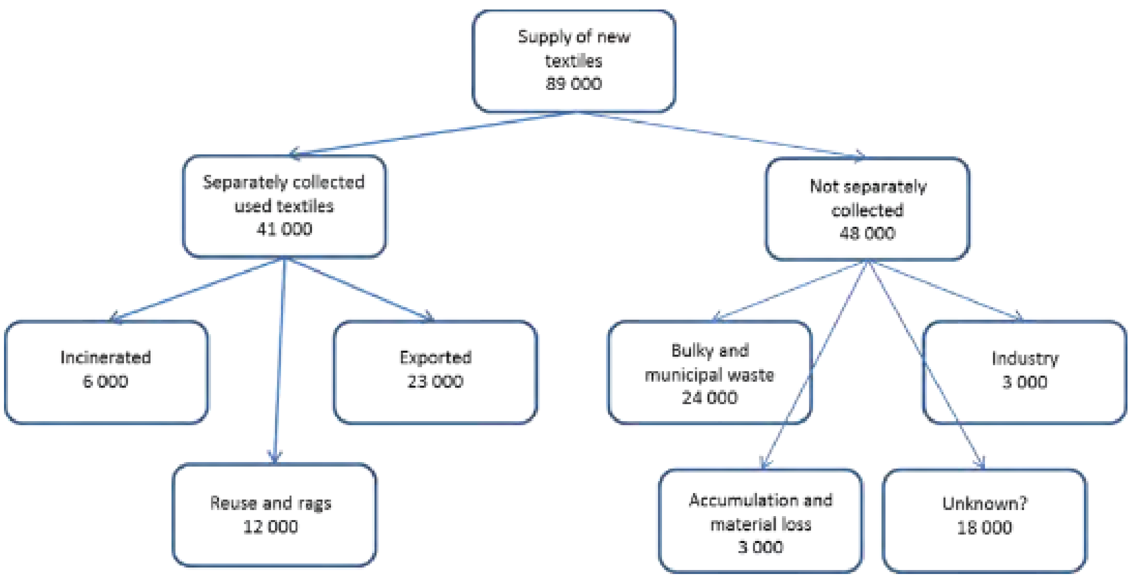

Figure 6:Estimated Textile Flow (in tons) in Denmark, 2010, from Palm et al (2014b) using data from Tojo et al (2012) and Watson et al (2014)

Municipalities are responsible for the collection, sorting, reuse and recycling strategies of household waste. This can include textiles along with other recyclable items (Palm 2015). However, humanitarian organizations and private collectors are currently driving collection of textiles. As it stands, Salvation Army, Danish Red Cross, Danchurch Social, and Trasborg are the four main collectors of textiles in Denmark (Table 1, see page 12).

Although Denmark has taken steps to increase textile collection, improvement of textile sustainability could be further expanded as textile collection is primarily focused on materials that are discarded by individuals rather than larger corporations (Palm et al. 2014). Wholesalers and retailers generate textile waste in the form of unsold, unworn product, and damaged product (Palm et al. 2014). According to Palm, there is no data regarding the handling of waste generated by wholesalers and retailers, which suggests that textile reuse could possibly be improved by expanding the target audience for collection.

Thus, the major events that lead to textiles being removed from circulation in Denmark are exportation and incineration. When textiles are removed from circulation in a country, the only way to replenish them is to increase consumption. Therefore, textiles must be kept in circulation longer through reuse to make Denmark's textile economy more sustainable.

Efforts being made to address the environmental impact of textiles

Solution 1: Altering production

Consumers are becoming more conscious of the impact of textile production and are beginning to display a preference for eco-friendliness, forcing companies to produce eco-conscious products (Challa 2014). The Sustainable Apparel Coalition is a nonprofit organization that has pioneered the Higg Index—a groundbreaking self-assessment tool that is used to empower brands to measure their environmental, social, and labor impacts, and in-turn identifies areas for improvement. One of many brands that have applied the measurements outlined in the Higg Index is Adidas. This company's efforts include avoiding oil-based plastic to reduce carbon emissions, using thinner or lighter materials to reduce waste and embedded carbon, and dry-dying clothes to save water, chemicals, and energy. An advertisement part of the less waste campaign can be seen in Figure 7.

Figure 7:Adidas advertisement for less waste campaign (Adidas 2016).

Solution 2: Textile Reuse

Textile reuse is a main component of increasing textile sustainability. As defined by Tojo et al, reuse includes “any operations by which products or components that are not waste are used again for the same purpose for which they were conceived” (2012, 15). By reusing instead of discarding, resources are saved as discarded clothes still contain approximately 70% of their life (Farrant et al. 2010). Furthermore, the energy consumed to reuse polyester and cotton only requires 1.8% and 2.6% of the respective production energies of those materials (Farrant et al. 2010). Thus, reusing textiles increases sustainability by conserving both resources and energy. As seen in Figure 6, much of the used textiles collected in Denmark end up in the separately collected sector. Of the 41,000 tons of textiles collected by charities and second hand shops in 2010, 23,000 tons were exported (Watson et al 2014). However, the export figure is much higher for the larger collectors; for the largest 13 collectors in Nordic countries 85% is exported for sorting, reuse and recycling in other countries (Watson et al. 2016).

The first destinations of textiles exported from Denmark are possible to track via contact with the collecting organizations. The top 13 Nordic collectors export directly to 35 different countries across the globe. Three quarters of exported textiles are exported in an unsorted state. These are mostly exported to Eastern European countries with large sorting facilities that act as interim destinations for the textiles (Watson et al, 2016). Once the textiles are sorted, they either can stay in that country or can be exported. The destination of the textiles after they go through the sorting facilities is harder to track since most of the collectors do not have influence on their fate. Only 23% of the Nordic collectors have direct control over the eventual fate of the textiles (Watson et al, 2016). This lack of influence over the fate of the textiles is a major reason why tracking the flow of textiles is so difficult and why their eventual fate is difficult to follow. Export of second-hand textiles and its complexities will be further addressed later on.

Reuse of clothing in Denmark is not insignificant but could be increased. It was estimated that 12,500 tons were resold in Denmark in 2010 via charity second hand shops (Watson et al 2014). Private consumer to consumer reuse is much more difficult to estimate. This includes selling used textiles online, giving used textiles to family members, and repurposing textiles within the home (Tojo et al. 2012). Of these informal reuse options, only online sales can be tracked (Tojo et al. 2012). Online companies and flea markets have seen a recent rise in use (2013a). Popular Danish-based companies such as “Den Blå Avis” and Trendsales facilitate online clothing trades. Watson et al (2014) estimated online sales via these two companies and others to be at least 1,500 tons per year but could be higher. Additionally, luxury second-hand shops are also becoming more popular, especially in the larger cities (Tojo et al. 2012). While resale of used textiles is becoming increasingly popular, it is necessary to further expand this practice in order to increase textile sustainability.

Current collection of textiles for reuse is conducted primarily by charitable organizations (2013a). The six main collectors in Denmark include five humanitarian organizations, Røde Kors (Red Cross), Frelsens Hær (Salvation Army), Kirkens Korshær (Dan Church Social), UFF, and Folkekirkens Nødhjælp (Danish Church Aid), and a privately-owned actor Trasborg (Tojo et al. 2012). Textiles are primarily collected via public containers located at drop-off centers and shops; however, textiles are collected via door-to-door pickups in limited quantities (Palm et al 2014b). Each organization has a different procedure for dealing with textiles. Trasborg (as the only Nordic example) carries out detailed sorting in Denmark and then exports 100% of the reusable items for sale elsewhere. Frelsens Hær and Røde Kors take only quality items for resale in their own domestic shops and sends the remainder for sorting in other countries while UFF exports all the textiles they collect in unsorted state (‘original’) to their sorting facilities in Eastern Europe (Watson et al 2016).

As shown in Table 1 below, Trasborg has a higher incineration percentage than any of the humanitarian organizations. This is because Trasborg discards a greater quantity of textiles during the first sorting, thus causing humanitarian organizations to have higher reuse rates; this is primarily because sorting is carried out in Denmark where markets for recycled textiles are small. Based on the estimated total values, approximately 15% of collected textiles were incinerated (Watson et al, 2014). In order to increase textile sustainability, Denmark must seek to extend the life of this 15% through alternative methods such as recycling.

Table 1: Summary of estimation in tons of textile collection, reuse, exports, and incineration per actor in Denmark, adapted (Watson et al. 2014)

	Antal butikker	Indsamling	Genbrug	Eksport	Forbrænding
Trasborg	-	7.000	-	4.200	2.800
Røde Kors	**200**	6.000	600	4.800	600
Frelsens Hær	**20**	7.500	750	6.000	750
UFF	-	1.200	-	1.080	120
Kirkens Korshær	**240**	5.000	4.500	0	500
Folkekirkens Nødhjælp	**111**	500	250	220	30
Andre*	**600**	12.000	6.400	4.400	1.200
Consumer to consumer	-	-	1.500	-	-
Total (afrundet)	**1.170**	**39.000**	**14.000**	**21.000**	**6.000**

One main issue with textile reuse is individual responsibility. In the waste prevention strategy, Denmark without Waste II, it was found that between 2003 and 2010 consumption of clothes and other textiles by households went up by 36% (2015). However, consumers were estimated to have discarded half of the textile products they obtained to be incinerated, rather than reused or recycled. While it may seem that the increased consumption and startlingly high rate of disposal demonstrates a lack of consumer awareness regarding the environmental cost of textile consumption and the potential of textile reuse and recycling, there are other factors that could be influencing these increases. For example, the frequency of buying, pleasure, and the price are the main factors for increased textile consumption (Farrant et al. 2010). The complexities this issue presents warrant further investigation.

Solution 3: Recycling

Certain fractions of textiles are often not suitable for reuse but can still be recycled. In the years leading up to 2011, 6,000 tons of industrial wipes were generated in Nordic countries by recycling textiles (Tojo et al. 2012). This process provided jobs and saved on incineration costs; however, this practice has been discontinued.

Currently, textile recycling in Denmark is minimal (Palm et al. 2014b). Recycling textiles is the reprocessing of textile waste into new products, which can be done as 99% of used textiles are able to be recycled (Gadkari and Burji 2015). The environmental benefits of recycling textiles include reduction in petroleum usage, reduction of greenhouse gases, and conservation of energy (Gadkari and Burji 2015). Of the 59,300 tons of textiles discarded by users and collected in Denmark in 2010, around 140-180 tons of those textiles were recycled in Denmark (Tojo et al. 2012).The major recycling processes in Denmark include cutting textiles into pieces to sell them as industrial wipes and making textiles into cloths to be re-sold (Tojo et al. 2012). Previously, the municipality of Haderslev collected used textiles at the local recycling depot to be sent to the recycling facility, where the textiles were cut into industrial wipes as a social project (Palm et al. 2014). The practice has been suspended as they were operating out of their jurisdiction; municipalities are not authorized to carry out processes that are carried out by privatized companies. This is one example of political complexities that arise while investigating this subject.

The remainder of the textile recycling comes from the trade organization for laundry and textile cleaning called Brancheforeningen for vask og tekstiludlejning (BVT). BVT estimates that around 80-100 tons of used textiles a year are re-sold as cloths consisting of mainly cotton or cotton/polyester textiles (Tojo et al. 2012). Dantextil (a Danish Organization) exports additional textiles with recycling potential to other European countries to be recycled (Palm et al. 2014). Dantextil receives around 5-6,000 tons of used textiles from collection organizations in Denmark a year (Palm et al. 2014). These used textiles are not wanted by other organizations for selling purposes; therefore, these textiles are exported (Palm et al. 2014). To decrease the amount of textiles incinerated, recycling must be used as a subsequent step to reuse in Denmark and other countries in cooperation with Denmark in order to decrease environmental burden of textiles.

Solution 4: Exporting

Currently, Denmark exports approximately 75% of its reusable textiles due to a lack of demand for second-hand clothes (SHC) and economic challenges with respect to operating sorting facilities within Denmark (Table 1), although there is one sorting facility run by Trasborg that carries out detailed sorting. Nordic used textiles are exported to 115 different countries, with about 82% exported to 10 primary countries (Watson et al 2016). Of the 10 countries that make up the majority of direct exports, only one is outside of the EU (Watson et al 2016). About 60% of the collected textiles from the four biggest collectors in Denmark are exported in their original state (Watson et al 2016), the rest are exported in a presorted state. The Danish collectors receive around 6 DKK/kg for unsorted (‘original’) textiles (Watson et al, 2016). These unsorted textiles are almost exclusively exported to EU countries for sorting. Once these textiles are sorted, the non-reusable textiles either remain in the sorting country for down-cycling, or are shipped to eastern Asia for mechanical recycling (Watson et al, 2016). Very little sorting is done outside of these countries but sorted textiles that are reusable are exported all over the world.

The final destination of Nordic textiles mostly comprise other European countries, but a large portion have a final destination outside of the EU. India, Pakistan, and African nations make up about 30% of the final destinations for SHC as there is a large demand there (Watson, 2016). However, experts have differing opinions as to whether or not exporting to these countries is an effective means of handling SHC. An INDEX article argues that this practice is detrimental to the African countries as it places huge environmental and economical burdens on the countries (2013b). On the other hand the import of used textiles creates thousands of jobs. In Nairobi alone the used textile market is estimated to provide 65 000 jobs (Crowe 2014). Moreover, since only sorted wearable quality textiles are exported to Africa from the Nordic countries, waste generation and environmental impact is probably low. Nevertheless, some African countries inhibit imports of used textiles via bans, restrictions, and prohibitively high taxes as a political stance to protect their new textile industries (Watson et al, 2016). Per contra, Dr. Simone Fields argues that the commercialized SHC trade in Sub-Saharan Africa is beneficial as there has been a rise in poverty which makes inexpensive clothing options necessary (Fields 2003). However, Dr. Field study does not address any of the environmental ramifications of the SHC trade. Watson et al, 2016 are currently carrying out field studies in receiving countries to determine how impacts can be reduced and benefits increased via closer control of the fate of textiles exported to Sub-Saharan Africa at these volumes reaching close to 12,000 tons a year (Watson, 2016). While the SHC may be largely reused initially, once the clothing is no longer wanted, it is landfilled since there are no reuse systems in place (2013b). In her study “Environmental Benefits of Reusing Clothes,” Farrant reaches a similar conclusion as the INDEX article (Farrant, Olsen and Wangel 2008). As described, this current system is not sustainable; collectors in Denmark are simply exporting the problem.

Textile sustainability initiatives occurring outside Denmark

Initiatives in Europe (UK)

The United Kingdom is also seeking to increase textile sustainability. In 2010, the UK presented a revised action plan for increasing textile sustainability (2011). The action plan focuses on the following areas (2010, 9):

1. Improving Environmental Performance across the Supply Chain

- Sustainable Design
- Fibres and Fabrics
- Maximising Reuse, Recycling and end of life management
- Clothes Cleaning

2. Consumption trends and behavior
3. Awareness, media, education and networks
4. Creating market drivers for sustainable clothing
5. Instruments for improving traceability along the supply chain (ethics, trade and environment).

While this UK action plan bears similarities to the action plan proposed by the Nordic Council of Ministers, there are some differences in focus and approach (Palm et al. 2014). Therefore, both regions could benefit from communicating and sharing ideas for increasing textile sustainability.

The UK is currently behind Denmark in efforts to improve textile sustainability. According to a study conducted by Woolridge et. al, 4-5% of the current municipal waste stream in the UK is textiles; of this fraction, approximately 25% is recycled or reused by companies such as Salvation Army (Woolridge et al. 2006). The remaining 75% is either landfilled or incinerated (Woolridge et al. 2006). When compared with previously mentioned statistics, the UK is incinerating/landfilling approximately 55% more textiles than Denmark.

Although the UK is behind Denmark in textile sustainability, their current reuse system is quite similar to that of Denmark. Humanitarian organizations, such as the Salvation Army, SCOPE, BHF, and Oxfam, are the proprietors of approximately 85% of the textile collection banks (Woolridge et al. 2006). However, the UK has also implemented curbside collection of textiles for approximately 1 million homes. In a study conducted by Karousakis and Birol, residents reported that they desired curbside collection for textiles and would be willing to pay for curbside collection; the author concludes that a cost-benefit analysis should be conducted to see if increased curbside collection would be beneficial (Karousakis and Birol 2008). Based on these findings, Denmark should also consider using curbside collection in order to increase textile sustainability.

Recycling Initiatives in Other Countries

In order to optimize recycling within Denmark, it is necessary to move towards advancing large-scale textile recycling processes, as is seen in other countries. The Nordic council has researched current recycling advances that can be broken down into improvements in sorting, mechanical recycling, and chemical recycling (Palm 2015). There is a current project taking place called T4T INDENTITEX, which aims to sort textiles on an industrial scale (Palm 2015). This technology could be useful for sorting textiles into fibers for recycling, while at the same time, using little manpower and lowering the cost for textile recycling (Palm 2015). This technology could be utilized in order to reduce worker costs in Danish textile recycling plants.

In France, the company Le Relais has taken great strides in performing different types of mechanical recycling like shredding, tearing, and cutting for insulation or wipers (Palm 2015). Le Relais operates with 90,000 textile containers, which is a large-scale recycling process that can be used as a model for recycling facilities in Denmark (Palm 2015). Au Dela Du Fil (France) produces yarn from industrial textile waste and post-consumer textiles to be used for the production of other textiles (Palm 2015). The yarn produced is of a lower quality (also known as down-cycling) than manufactured textile fibers; processes to improve quality are still under investigation. The Japan Environmental Planning Co Ltd has a target of recycling all clothes sold and worn in Japan (2012, just-style management briefing: Textile and clothing recycling worldwide). They helped retailers like Uniqlo collect clothes for the UN High Commissioner for Refugees and other aid organizations to turn used clothes into heat insulation fabrics, gloves, and fuel (2012, just-style management briefing: Textile and clothing recycling worldwide). In 2010 alone, 2.6 million clothes were recycled through their efforts (2012, just-style management briefing: Textile and clothing recycling worldwide).

The last form of large scale recycling, chemical recycling, is still not fully developed; however, there is one company in Japan, called TEIJIN, that is leading the way. The current process developed by TEIJIN is the recycling of polyester clothing with polyethylene terephthalate (PET) to produce a material similar to polyester (Palm 2015). The cost to do this is two to three times higher than producing polyester so further technology and innovations are needed to make this a feasible recycling method (Palm 2015). Clearly, Denmark should further investigate large scale recycling in order to minimize further production of textiles.

Steps Denmark is Taking to Increase Textile Sustainability

The Danes have progressed toward a more sustainable society but have not yet reached their full potential. Denmark has launched a “Denmark without Waste II” initiative to diminish the environmental impact of textiles and other wastes through prevention. Unfortunately, as good as “zero waste” sounds, the incentive to produce less waste is lacking. The municipalities in Denmark generally have their own incinerators to produce energy for the town. When less waste is incinerated, the incinerator is not working at full capacity; therefore, there is an incentive to create more waste in order to create more energy by incinerating waste (Zero Waste Europe 2014). There is clearly a gap between the direction Denmark wishes to take and the level of understanding the residents and companies possess.

The Nordic region has also launched multiple initiatives to develop other solutions for textile sustainability. For example, "The Nordic Working Papers" published a proposal by Nielsen & Schmidt (2014) to change "consumer behavior towards increased prevention of textile waste" (Nielsen et al. 2014). The proposal argues that a reduction in consumption of new textiles, demand for durable textiles, eco-efficiency, and cleaning cloth correctly and less often are targets to change the negative effects of textile waste (Nielsen et al. 2014). Unfortunately, similar to the zero waste campaign, consumers and stakeholders are not well informed of the negative effects of textile waste and therefore campaigns and proposals are not fully effective.

The Danish Waste Association (Dansk Affaldsforening) is working toward connecting the community to fill in the gaps between legislation and the municipalities and stakeholders. One of the objectives of the association is the "promotion of cooperation, knowledge-sharing, and dissemination of knowledge among members together with related organizations, associations, and other stakeholders." (About Danish Waste Association). As shown in Figure 1, textiles have a long and complicated supply chain. It is for this reason that humanitarian organizations, second-hand retailers, municipalities and any other stakeholders must cooperate in order to further each other's efforts in reducing the environmental burden posed by textiles. As it currently stands, Denmark lacks a clearly defined flow for textile reuse and recycling. In a policy brief on Nordic textile reuse and recycling commitment, David Palm of the Swedish Environmental Research Institute states that clarification of ownership of used textiles and textile waste is needed (2013a). He suggests that both reusable and recyclable textiles be collected in a single, unseparated fraction as consumers are not capable of separating textiles into the appropriate fractions or categories (Palm 2015). Some charities such as Red Cross have recently begun accepting all kinds of used textiles in their containers and not only textiles suitable for reuse.

However, Tojo states that "different municipalities differ in terms of how forthcoming and supportive they are towards charity collectors," therefore, "the role of municipalities [should] be made clearer and that municipalities should be encouraged to collaborate with these collectors" (2012, 58). This collaboration would allow the municipalities and humanitarian organizations to share the financial burden of collecting used textiles. It is clear that municipalities and stakeholders (i.e. humanitarian organizations and private collectors) should collaborate;

however, the manner and extent of collaboration requires further investigation. By encouraging cooperation between members of the Danish Waste Association, they are more likely to be unified, and initiatives are more likely to be successful. The DWA also intends to find problem areas and relay possible solutions to their members and stakeholders. Efficient communication between municipalities, the association members, and legislation is a key factor in successful implementation of effective waste practices.

Our goal is to assist the Danish Waste Association in their efforts to reduce the environmental impact of textiles by filling in gaps in the textile life cycle. There are many places in the life cycle where textiles could be relocated but instead are getting incinerated or exported, amongst other methods. We believe that, with more communication between each stages of the life cycle, Denmark can work toward a more sustainable consumption of textiles.

Methods

This project assisted the Danish Waste Association's efforts to reduce the environmental footprint of textiles by increasing reuse and recycling through optimizing textile collection methods and cooperation between stakeholders of humanitarian organizations and municipalities. The team developed and carried out the following objectives in order to accomplish this mission:

1. Assess current textile reuse and recycling systems
2. Identify similarities and differences in approaches to reusing and recycling textiles among different organizations in Denmark
3. Facilitate stakeholder cooperation via a workshop on methods to optimize the reuse and recycling of textiles

Objective 1: Assess current textile reuse and recycling systems in Denmark

Denmark's current reuse system is facilitated primarily by humanitarian organizations and a few privately owned companies. In order to better understand how each company operates—collecting, sorting, and assigning product destination— we interviewed several of the most prominent stakeholders involved in the textile reuse and recycling industry as follows: Red Cross, Danish Church Aid, Ulandshjælp Fra Folk Til Folk (UFF), and Trasborg. Through semi-structured interviews, we gathered information regarding:

- Each organization's current practices regarding collection, sorting, and assigning product destinations
- Each organization's statistics for product destination and where these statistics can be found (public vs. private)
- What areas of operations each organization thinks it does well
- What areas of operations each organization thinks need improvement
- What each organization hopes to gain from this project

Through this line of inquiry, we learned about each of the stakeholders' views on textile reuse and recycling. After the interviews, we constructed a quantitative code in order to quantitatively evaluate the interviewees' responses. The specific questions that we used in these interviews can be found in Appendix 1. All members securely stored information obtained during interviews on password protected devices.

In addition to interviews with stakeholders, we engaged with the following waste companies owned by Danish municipalities in order to document their current textile waste infrastructure: Vestforbraending, Amager Resource Center, Dansk Affald, Arwos, and Renosyd. Through semi-structured interviews with representatives from each company, we gained information about:

- How the textiles are currently being collected separately in these municipalities
- How are the textiles being sorted
- Current flow of textiles in these municipalities
- What limitations are present that prevent recycling of textiles in these municipalities
- What can the Danish government do to persuade municipalities to recycle more textiles

Through these questions we learned more about the limitations that are preventing municipalities from co-operating with humanitarian organizations and optimizing the reuse and recycling of textiles. After the interviews, we constructed a quantitative code in order to evaluate the interviewees' responses. The specific questions that we used for these interviews can be found in Appendix 2. All members securely stored information obtained during interviews on password protected devices.

Similarly, we interviewed consultants to assess the overall picture of the textile industry. Our primary contact was with David Watson, a consultant from PlanMiljø. His extensive work with textiles made him a valuable resource when considering all aspects of the lifecycle of textiles. We also spoke with the senior researcher of the joint UFF-DTU research project on reuse and recycling of textiles to investigate the most recent statistics and get a more technical perspective. We conducted discussions with a consultant from Isobro and the EPA in order to further investigate the legal responsibilities as outlined by these lobbyists and their guidelines.

Notes from all interviews can be found in appendices 4-17.

Objective 2: Identify Similarities and Differences in Approaches to Reusing and Recycling Textiles Among Different Organizations in Denmark

Through our efforts in objective one, we were able to compare and contrast the systems of each organization. In order to effectively quantify these similarities and differences we developed a cost-benefit analysis. We used the analysis to highlight the need for increased textile collection through demonstrating significant environmental and financial benefits. From this data, we produced projections based on increased collection of textiles. The criteria we used to monetize and evaluate each cost and benefit are displayed in Table 2. In addition to the monetized values in the table, we included the effects of environmental impacts. This was necessary due to the high significance in our project, and to provide an accurate comparison of the benefits.

Table 2: Criteria for performing a cost benefit analysis.

Cost or benefit	**How we monetized and evaluated them**
Cost to separately collect textiles that are currently being placed in bulky waste	- Additional collection bins set up for humanitarian organizations - Collection bags given to households
Cost to sort collected textiles from different waste streams	- Labor to sort textiles from recycled streams
Profit from selling collected textiles	- Amount of collected textiles that are: reusable, recyclable, or energy recoverable - Selling price of collected textiles per ton - Price municipalities charge humanitarian organizations per ton of textiles
Environmental Benefits from increased collection of textiles	- Percent of collected textiles that are: reusable, recyclable, or energy recoverable - CO_2 savings per ton of textiles separately collected - Water savings per ton of textiles separately collected

We determined the cost and profits for increased separate collection of textiles by basing the cost-benefit analysis off of the collection models being tested at the Amager Resource Center (ARC) and Dansk Affald. The humanitarian organization UFF has a contract with the ARC that allows them to have 50 collection bins at the ARC recycling centers. In return UFF pays ARC a set amount for each ton of textiles that is collected. During interviews with representatives for both parties, we obtained the costs for each step of this process as well as the expected benefits, and after which, generated a model of this collection strategy in order to show aggregate profit for both partners over a five-year period. We determined the profits for the ARC using equation 1 below and determined the profits for UFF using equation 2.

$$ARC = Aprice * w * t - 50 * b \tag{1}$$

Aprice = Price (DKK/ton) ARC sells the collected textiles to UFF

w = predicted collected textiles from new bins (tons/year)

t = time (years)

b = price of a bin (DKK)

$$UFF = (Uprice - Aprice) * w * t \quad (2)$$

Uprice = price UFF expects to sell collected textiles from ARC (DKK/ton)

Dansk Affald is currently testing a new collection method for textiles involving curbside collection in their DuoFlex™ bin sorting system. They currently have the DuoFlex™ bins at all of the households in the municipalities that they service; therefore, the only added costs would result from providing plastic bags for these households to package used textiles and the labor hours needed to separate the bags out of the paper and cardboard streams at the waste management facility. Dansk Affald has collected data for the first 3 months of 2016 and will maintain the trial for the duration of the year. Based on the data collected in the trial so far, we used equation 3 to determine the amount of profit a municipality could gain from curbside collection with a similar system.

$$DAprofit = w * p - b * bprice - h * lprice \quad (3)$$

DAprofit = Dansk Affald profit from curbside collection of textiles (DKK/year)

w = projected textiles collected a year curbside (tons/year)

p = price that the collected textiles can be sold for (DKK)

b = number of bags given to households a year

bprice = price of each bag (DKK)

h = extra hours to sort out the textiles collected (hr)

lprice = price of sorting labor (DKK/hr)

We also used the cost benefit analysis to show the impact of increased collection on the environment, municipalities, and collectors on a national level. We estimated that money could be made by municipalities with separate collection as opposed to incineration. We used equation 4 to determine how much profit could be generated by increasing the percentage of textiles collected and thus, decrease the percentage incinerated. This equation is based on the assumption that the municipalities do not cooperate with other collectors and only sell the collected textiles to sorting facilities abroad.

$$M = P * i * mprice \quad (4)$$

M = money (DKK) made for municipalities

P = potential collectible textiles in Denmark (in tons)

i = percent increase in collected textiles

mprice = price municipalities sell to textile handlers (DKK/ton)

We also considered the possibility of municipalities working with collection organizations via contracts that allow them to buy the collected textiles, as modeled by the UFF-ARC contract. Using equations 5 and 6, the team calculated the potential profits for both collection organizations and municipalities that are abiding by this model.

$$M1 = P * i * mprice \tag{5}$$

M1 = money (DKK) made for municipalities

P = potential collectible textiles (in tons)

i = percent increase in collected textiles

mprice = price municipalities sell to textile handlers (DKK/ton)

$$M2 = P * i * (price - mprice) \tag{6}$$

M2 = money (DKK) made for collection organizations

P = potential collectible textiles (in tons)

i = percent increase in collected textiles

mprice = price municipalities sell to collection organizations (DKK/ton)

price = price collection organizations sell textiles for (DKK/ton)

The last aspect of the cost benefit analysis was to determine the environmental impact from increased collection. Although we could not monetize these points, we included this data with the cost benefit analysis due to its central nature, as the overarching goal of this project is to reduce the environmental footprint of textiles. We calculated water savings from increased collection using equation 7 assuming an optimistic 1:1 substitution factor. Another assumption was that 80% of collected textiles would be reused, 15% would be recycled, and 5% would be incinerated. To determine the possible decrease in carbon dioxide emissions, we used equation 8 with the same assumptions used to determine the decrease in water usage.

$$WS = P * i * (pR * wR + pRe * wRe + pI * wI) \tag{7}$$

WS = total water savings (in tons)

P = potential collectible textiles (in tons)

i = percent increase in collected textiles

pR = percent of reusable textiles in collected textiles

wR = water saved from reusable textiles collected (tons of water / ton of textiles)

pRe = percent of recyclable textiles in collected textiles

wRe = water saved from recyclable textiles collected (tons of water / ton of textiles)

pI = percent of incinerated textiles in collected textiles

wI = water saved from incinerated textiles collected (tons of water / ton of textiles)

$$CS = P * i * (pR * cR + pRe * cRe + pI * cI) \tag{8}$$

CS = total water savings (in tons)

P = potential collectible textiles (in tons)

i = percent increase in collected textiles

pR = percent of reusable textiles in collected textiles

cR = CO_2 emissions saved from reusable textiles collected (tons of CO_2 / ton of textiles)

pRe = percent of recyclable textiles in collected textiles

cRe = CO_2 emissions saved from recyclable textiles collected (tons of CO_2 / ton of textiles)

pI = percent of incinerated textiles in collected textiles

cI = CO_2 emissions saved from incinerated textiles collected (tons of CO_2 / ton of textiles)

Objective 3: Facilitate Stakeholder Cooperation via a Workshop on Methods to Optimize the Reuse and Recycling of Textiles

From site visits and interviews, we compiled conclusive information to be used in the development of a persuasive presentation for a stakeholder workshop. The presentation contained the current life cycle of a textile and specifically highlighted the importance of prolonging the end of life portion and the importance of increasing collection. These highlighted items were supported with a cost benefit analysis, interview data analysis, and content analysis. We also presented the stakeholders with a preliminary collection bin map and an informative pamphlet to be used to help educate individuals and increase collection. At the end of the presentation, we identified the gaps in the system that were discovered through background research and interviews. We presented these gaps in conjunctions with questions in order to facilitate discussion about developing and implementing strategies. The questions are as follows:

How can...

- Convenience increase for consumers, and correspondingly increase the volume of collected textiles?
- Contamination be minimized?
- Benefits be shared?
- The humanitarian organizations be included?
- Waste be defined, and who has ownership?
- Value Added Tax (VAT)-free status be maintained?
- The impact of exportation on the consumer be reduced?

We left the questions for consideration until the end of the day, after other members gave their own presentations. The workshop concluded with participants gathering together to discuss the proposed questions and develop solutions in a cooperative fashion. We each sat at different tables in order to facilitate discussion and record their suggestions, which can be found in appendix 18.

Results and Analysis

In this chapter presents the data acquired through the interviews and site visits conducted throughout the project, as described in the Methods chapter.

Interviews with Stakeholders

From our interviews with stakeholders, Objectives 1 and 2 which focused on an assessment of current reuse and recycling systems and a comparison of various strategies among companies within Denmark, were accomplished. The stakeholders seen in Table 3 were interviewed in order to understand the current reuse and recycling systems for textiles and to gain insight into potential areas for improvement. Through conversing with these individuals it was possible to more clearly see the potential in textiles as a resource.

Table 3:Table of interviewed representatives

Organization	**Type**	**Contact**	**Position**	**Date**
PlanMiljo	Consultant Firm	David Watson	Senior Consultant	March 15, 2016
Vestforbraending	Waste Management Facility	Morten Strandlod	Head of Marketing	March 16, 2016
Dansk Affald	Waste Management Facility	Jesper Vange Heinzl	Sales and Marketing Manager	March 29, 2016
Arwos	Waste Management Facility	Halfdan Neumann	Teamleader	March 29, 2016
Danish Church Aid	Humanitarian Organization	Morten Ebbesen	Head of Center	March 30, 2016
Renosyd	Waste Management Facility	Poul Pedersen	Career Counselor	March 30, 2016

Amager Resource Center	Waste Management Facility	Linda Rebien	Development Consultant	April 4, 2016
UFF	Humanitarian Organization	Kaj Pihl	Director	April 7, 2016
Isobro	Lobbyist Organization	Vibeke Anderson	Independent Consultant	April 7, 2016
Trasborg	Private Collector	Steen Trasborg	Owner	April 13, 2016
EPA	Government Agency	Anne-Mette Lysemose Bendsen	Consultant	April 14, 2016
Red Cross	Humanitarian Organization	Tina Donnerberg	Head of Commercial Activities	April 20, 2016

All of the interviews of individuals in Table 3 were informal and semi-structured. A complete summary of each interview can be found in Appendices 4-17. A quantitative code was constructed based off of the questions in Appendices 1 and 2. The code was designed to be categories that were exclusively disjunctive (Table 4). A dash was used for categories with missing data. The positive responses for each category were tallied and converted to percentages. As can be seen from the data in Table 4, the stakeholders operate similarly. The most notable piece of data was that all but one interviewed stakeholders viewed inter-stakeholder cooperation positively.

Table 4: Results from thematically coding our interviews

Organization	**Collection Strategies**		**Target Audience**		**Sorting Strategy**			**Unsorted Destination**		**Attitude-Coop**		**Salvage Criteria**		**Recycling Practices**		**Direct Export**		**Waste Capacity**		**Want from Project**	
	Bin	Curbside	None	Target	None	Minimal	Fine	Ship Out	Incinerate	Pos	Neg	Has	Doesn't	Incinerate	Sends for Recycling	EU	Asia/Africa	Can take More	Maxed	Perpective	Data
Vestforbrænding	Yes	No	Yes	No	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	-	-	Yes	Yes
Danish Waste	Yes	Yes	No	Yes	Yes	No	No	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	No	-	-	Yes	Yes
UFF	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Renosyd	Yes	No	Yes	No	No	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes
Arwos	Yes	No	Yes	No	No	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes
Danish Church Aid	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes	No	No	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes
ARC	Yes	No	Yes	No	Yes	No	No	Yes	No	Yes	No	No	Yes	No	Yes	No	No	Yes	No	Yes	-
Red Cross	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Trasborg	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	-	-
Percent Yes	**100**	**11**	**89**	**11**	**33**	**44**	**33**	**89**	**67**	**89**	**11**	**44**	**56**	**78**	**89**	**56**	**33**	**67**	**11**	**89**	**78**

Cost Benefit Analysis

To present our findings to the stakeholders, a cost benefit analysis was prepared to show the possible profit and environmental benefits of increased collection. Although environmental benefits are not monetized in the cost benefit analysis, they are imperative in this project and have a significant impact on the textile market. The cost and profits for increased separate collection of textiles based on the Amager Resource Center (ARC)-UFF trial over a five-year period are depicted in Table 5 below. As can be seen in Figure 8, both ARC and UFF are projected to experience increased profits over the five-year interval.

Table 5: Cost and Profits of increased separate collection of textiles based on ARC-UFF trial.

ARC model for collection						
Time (years)	0	1	2	3	4	5
ARC profit (thousands of DKK)	-50	630	1310	1990	2670	3350
UFF profit (thousands of DKK)	0	520	1040	1560	2080	2600

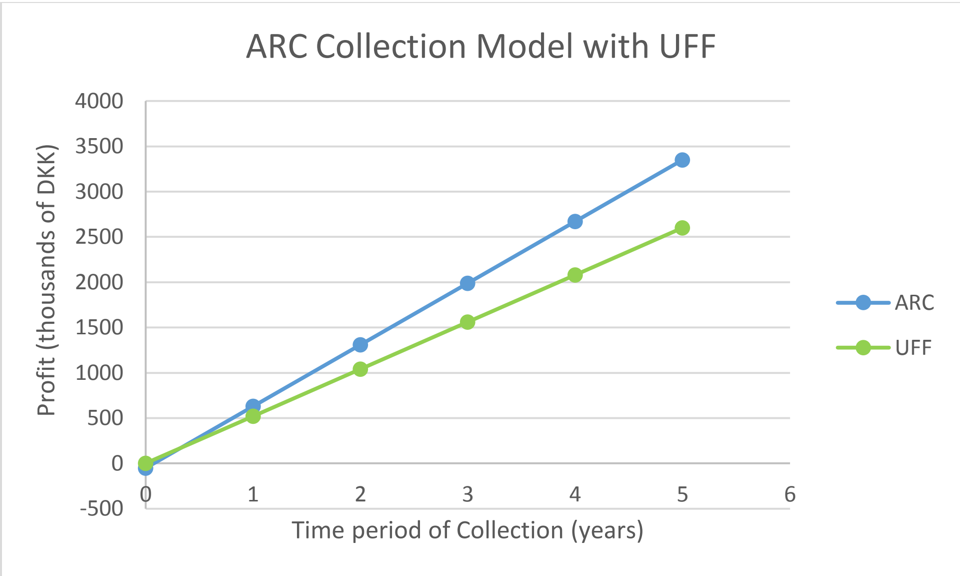

Figure 8: Graph representing aggregated profits for 5 years with increased separate collection of textiles based on ARC-UFF trial

As shown through the projections for the ARC-UFF cooperation, partnerships between municipalities and separate collectors are mutually beneficial. Data from this relationship suggests that future partnerships are a plausible option to increase collection and profit.

The results from the cost benefit analysis include the profit a municipality could gain from curbside collection with a similar system to Dansk Affald's Duoflex™ sorting bin. Table 6 shows the resources required and the overall profit based on tons of textiles collected. Figure 9 further demonstrates the positive, direct correlation between profits and collection.

Table 6: Resources required and profits based on tons of textiles collected.

Curbside collection model											
Projected collected textiles (tons)	0	5	10	15	20	25	30	35	40	45	50
Bags to collect textiles	0	4540	9080	13620	18160	22700	27240	31780	36320	40860	45400
Hours added	0	1.261111	2.522222	3.783333	5.044444	6.305556	7.566667	8.827778	10.08889	11.35	12.61111
Profit (thousands of DKK)	0	12.13728	24.27456	36.41183	48.54911	60.68639	72.82367	84.96094	97.09822	109.2355	121.3728

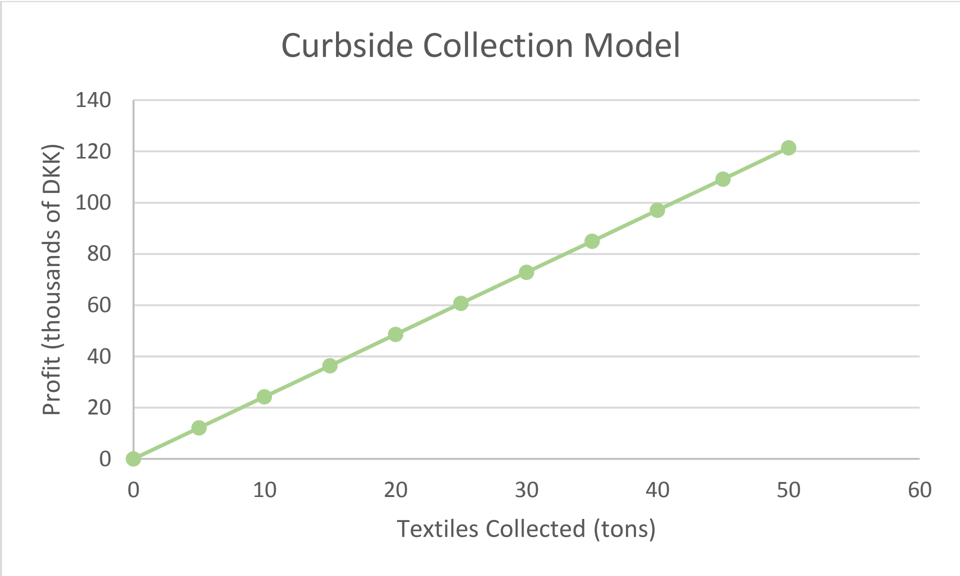

Figure 9: Graph representing profits based on tons of textiles collected with curbside collection

Data from the Duoflex™ system advocates for curbside collection. The profits along with the added convenience for residents make curbside collection another possibility for municipalities to increase collection of reusable or recyclable textiles.

With cooperation between municipalities and collectors, profits are available for each organization. Figure 10 below displays the money available through increased collection; just a 10% increase in collection could present a profit near 15 million Danish krone between municipalities and collectors.

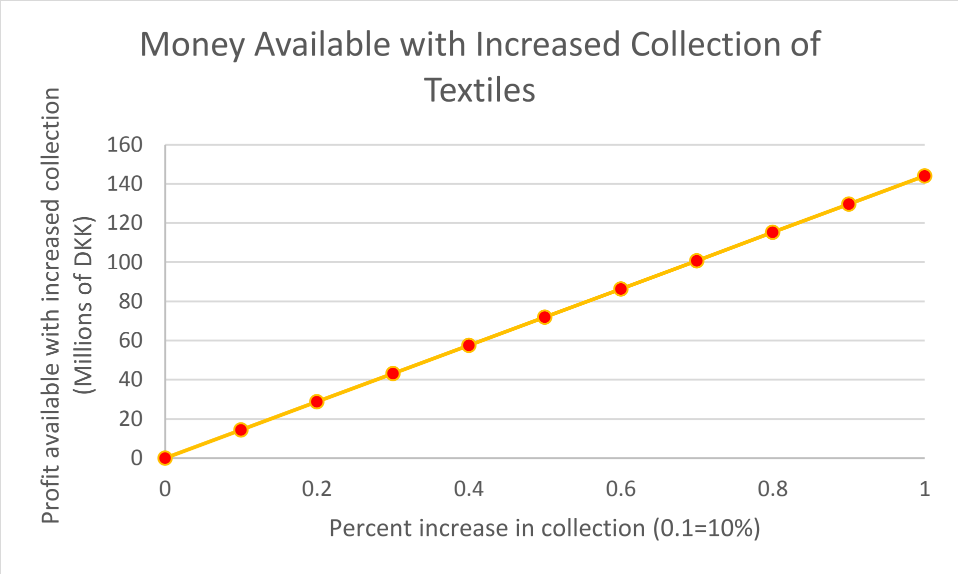

Figure 10: Graph of the money available with increased collection

To show the profit for municipalities, humanitarian organizations, and private collectors, calculations using equations 5 and 6 were carried out. The results of these equations can be found in Table 7 and are displayed in Figure 11.

Table 7: Money available to municipalities and humanitarian organizations and private collectors if they were to work separately

Percent increase in collection of textiles not being separately collected											
Percent increase in textiles collected	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Profit availible for municipalities (millions of DKK)	0	8.16	16.32	24.48	32.64	40.8	48.96	57.12	65.28	73.44	81.6
Profit availible for collectors (millions of DKK)	0	6.24	12.48	18.72	24.96	31.2	37.44	43.68	49.92	56.16	62.4

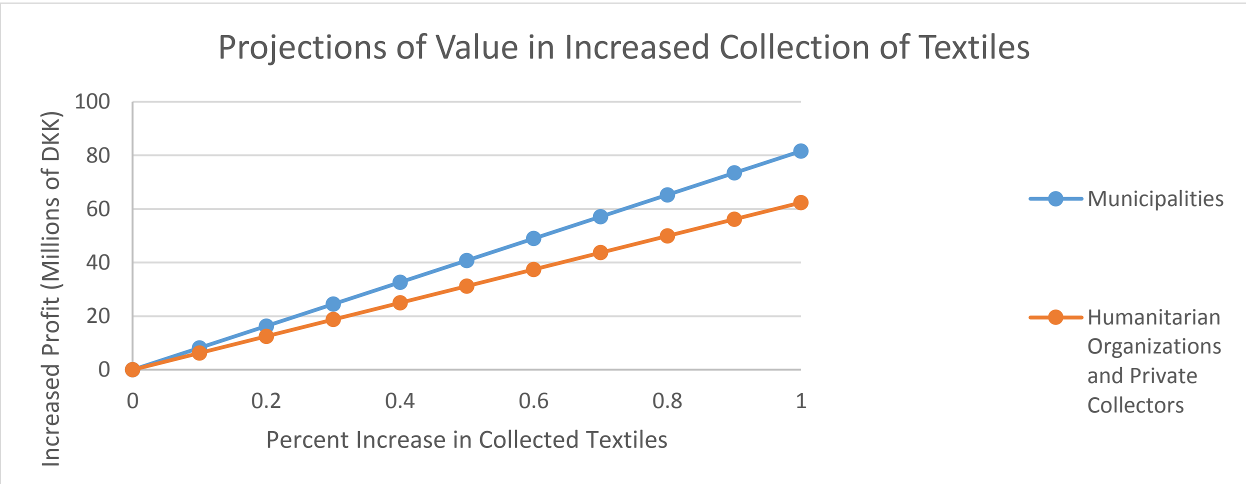

Figure 11: Graph displaying profit for municipalities, humanitarian organizations, and private collectors

The increase in profit for both municipalities and collectors exhibits that an increase in collection can benefit everyone, not just one kind of collector. With cooperation, every actor in textile reuse can reap benefits.

Apart from profit, increased collection poses global environmental benefits. Table 8 and Figures 12 & 13 display the decreases in the annual carbon dioxide emissions and water usage by Denmark when textile collection is increased.

Table 8: Environmental benefits of increased collection of textiles

Environmental Effect of Increased Collection in Textiles											
Percent increase in textiles collected	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Reusable textiles (tons)	28000	31840	35680	39520	43360	47200	51040	54880	58720	62560	66400
Water used through reuse (tons)	-1.3E+08	-1.4E+08	-1.62E+08	-1.8E+08	-2E+08	-2.1E+08	-2.3E+08	-2.48E+08	-2.66E+08	-2.83E+08	-3.01E+08
CO2 emissions through reuse (tons)	-588000	-668640	-749280	-829920	-910560	-991200	-1071840	-1152480	-1233120	-1313760	-1394400
Recyclable textiles (tons)	7000	7720	8440	9160	9880	10600	11320	12040	12760	13480	14200
Water used through recycling (tons)	-373605	-412033	-450461.4	-488889	-527317	-565745	-604173	-642601.3	-681029.3	-719457.3	-757885.2
CO2 emissions through recycling (tons)	-9100	-10036	-10972	-11908	-12844	-13780	-14716	-15652	-16588	-17524	-18460
Incineration grade textiles (tons)	55000	49440	44880	40320	35760	31200	26640	22080	17520	12960	8400
Water used through incineration (tons)	253148.5	227557.5	206569.2	185580.9	164592.6	143604.2	122615.9	101627.62	80639.3	59650.992	38662.68
CO2 emissions through incineration (tons)	-55000	-49440	-44880	-40320	-35760	-31200	-26640	-22080	-17520	-12960	-8400
Total water used from textiles in Denmark (millions of tons)	276.0265	258.5788	241.1357	223.6927	206.2496	188.8065	171.3634	153.92027	136.4772	119.03407	101.591
Total CO2 emissions from textiles in Denmark (hundred thousand tons)	12.169	11.40884	10.63868	9.86852	9.09836	8.3282	7.55804	6.78788	6.01772	5.24756	4.4774

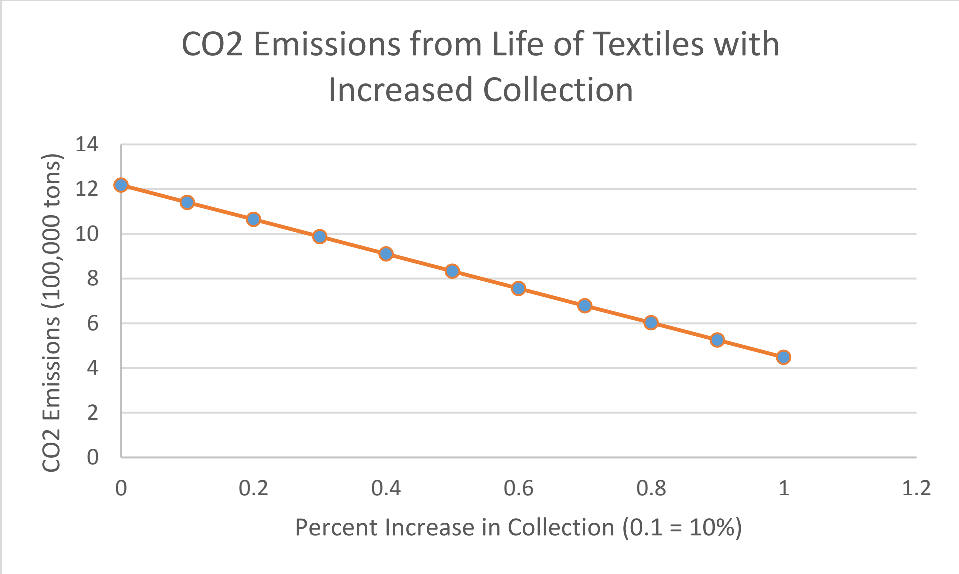

Figure 12: Graph displaying CO2 emissions prevented through increased collection.

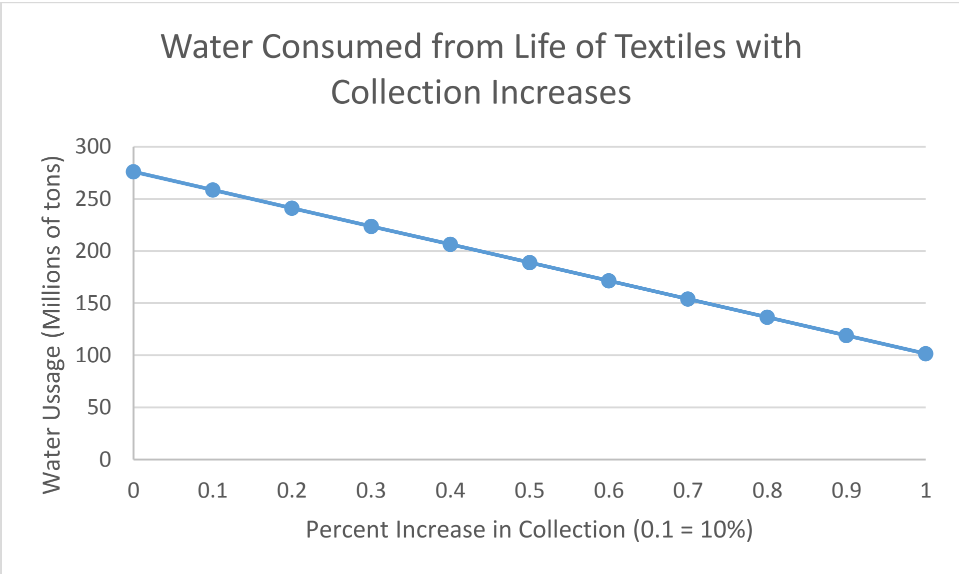

Figure 13: Graph of water consumption prevented through increased collection.

There are clear environmental advantages to increased textile reuse. With just a 10% increase in collection and subsequent reuse, near 30 million tons of water is saved and there is a decrease of near 100,000 tons of carbon dioxide emissions. The environmental benefits as well as the potential profit available to all operators in textile collection and reuse provide sufficient incentive for increased collection through cooperation.

Workshop

A workshop was held on April 27th, 2016 where members of the Danish Waste Association, humanitarian organizations, and waste management organizations could work together to find solutions to problems present in the textile management system. This event brought members from all aspects of the management system together, providing a unique opportunity for cooperation. Responses to the discussion topics are shown in Figure 14 below. This figure emphasized overlaps in responses and made it possible to develop five different areas for analysis.

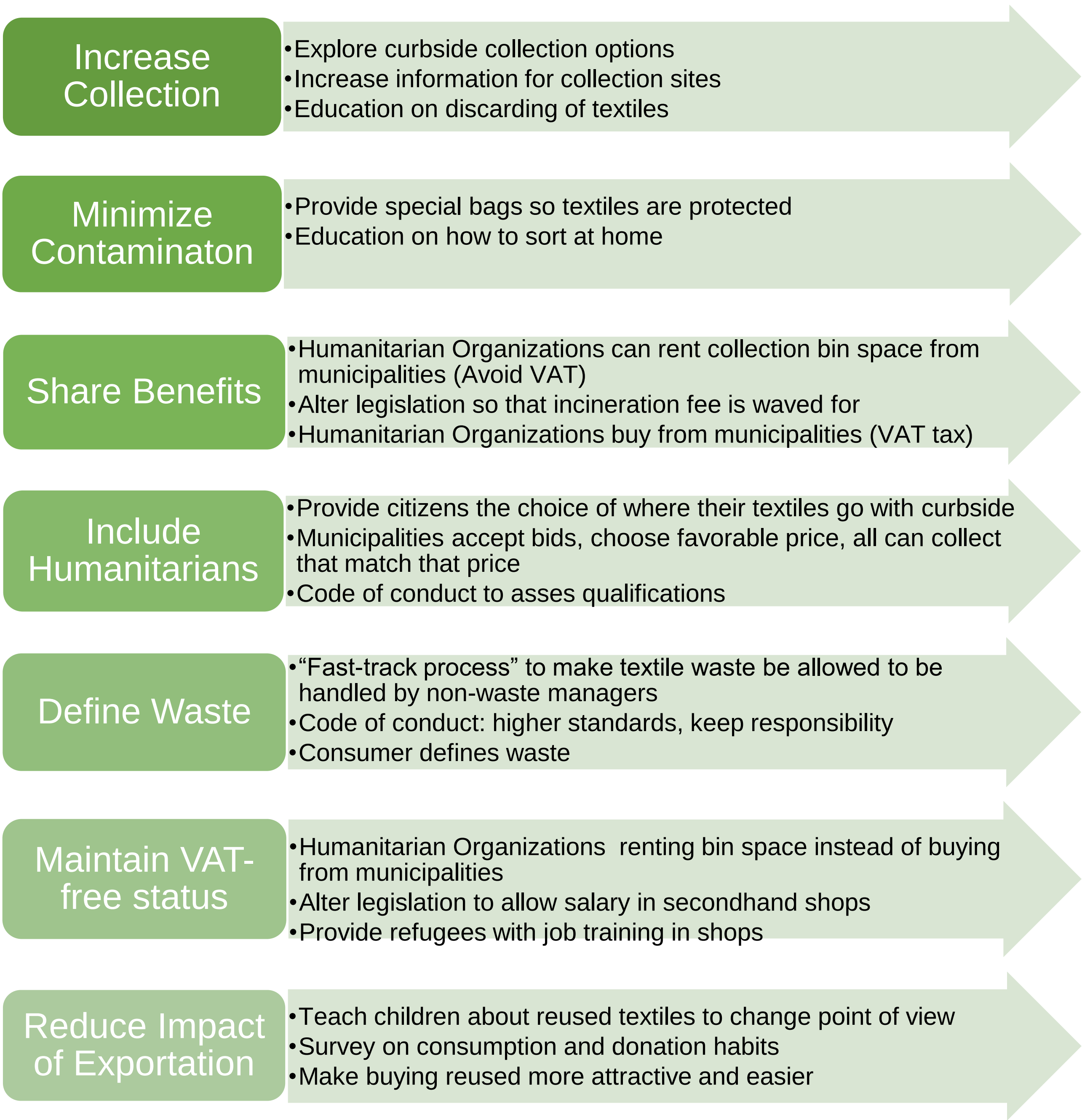

Figure 14: Results from workshop discussion topics

Analysis of VAT-Free Status

In order to encourage cooperation between humanitarian organizations and municipalities, humanitarian organizations must be able to maintain their VAT-free status. Current humanitarian-municipality cooperation models include municipalities collecting textiles in their recycling center bins and then selling the textiles on a per kilogram basis to humanitarian organizations. The primary issue with this form of cooperation is that humanitarian organizations have to export these textiles immediately after purchasing them in order to qualify for VAT-free status. The exportation of these textiles decreases the amount available to be sold in shops and eliminates that fraction of textiles for reuse within Denmark. During the workshop, a participant suggested allowing humanitarian organizations to purchase space for collection bins instead of paying for the textiles per kilo from the municipalities. This solution would allow the humanitarian organizations to remain VAT-free while selling collected textiles within Denmark. This form of cooperation would be beneficial for both stakeholders and thus, a trial for this should be considered for future implementation.

Another point of concern stems from the employment options available to humanitarian organizations. In order to maintain their VAT-free status, humanitarian organizations can only have volunteers operating their second hand shops. Meanwhile, municipality owned waste companies have recently begun opening second hand stores which are operated by paid employees, and thus, can be open for longer periods of time. These flexible hours of operation give the municipality shops a competitive edge over the humanitarian organizations who are limited by volunteer availability. One solution would be for the humanitarian organizations to take in refugees for job training at their shops. This option would allow the organizations to maintain their VAT-free status as well as provide them with a steadier work force to operate their shops on a constant basis. Members participating in the workshop also suggested developing legislation that would permit humanitarian organizations to have salaried employees in their second hand shops while maintaining their VAT-free status. This legislation change would make the competition even between both types of stakeholders' second hand shops.

Analysis of Sharing Benefits

In order to better facilitate stakeholder cooperation between municipalities and humanitarian organizations, the benefits of the industry must be appropriately shared. Current benefit sharing models between municipalities and humanitarian organizations were discussed during the workshop. These models included both Danish Church Aid's cooperation with Arwos and Renosyd as well as UFF's cooperation with ARC. Arwos sells the textiles that they are unable to sell in their second hand shop to Danish Church Aid who then exports them for a profit. Similarly, Danish Church Aid allows Renosyd to use one of their collection bins for their second hand shop, and in return, Renosyd sells the textiles that they are unable to sell in their shop back to Danish Church Aid to be exported. Currently, UFF buys textiles from ARC and then exports the textiles for a profit. During the workshop, some municipalities were in favor of these methods; however, some were not in favor of these methods as these relations included a bidding process in which the municipalities would select a single humanitarian organization to partner with each year. Several of the stakeholders believed this method to first, be unfair for other collectors and second, eliminate the citizens' option for determining the destination of their textiles. A possible solution would be to allow the citizens to vote on with whom their local municipality works. Another solution would be for the municipalities to cooperate with multiple humanitarian organizations; the municipality could select the most favorable bid provided by the humanitarian organizations and allow any organization that is willing to match the bid to collect textiles from them. An additional solution could be for municipalities to use the proposed code of conduct for humanitarian organizations when selecting a partner organization.

Another issue that is present with cooperation between humanitarian organizations and municipalities is the incineration fees that humanitarian organizations are charged. Currently, humanitarian organizations are the primary collectors and sorters of textiles, but with the collection of textiles comes unwanted waste in the bins as well. The humanitarian organizations are then required to sort out the waste and bring it to the municipalities to be incinerated. This process results in the humanitarian organizations paying an incineration fee even though their purpose was not to collect waste. After lengthy discussion during the workshop, it seemed unlikely that a legislation change to wave this fee would be successful. One potential solution would be to change the legislature to have textiles classified as waste that any organization could handle; this modification would allow humanitarian organizations to collect all textiles, and perhaps would be influential in changing the current Minister's opinion on waving the fee as humanitarian organizations would now be collecting all textile fractions. While these presented solutions were not positively received by every stakeholder, these solutions focus on each organization's different strengths in order to bring about cooperation between stakeholders.

Analysis of Educating the Consumer

Educating the consumer was a reoccurring topic when formulating solutions to the posed questions. Citizens play a vital role in successfully reducing the environmental footprint of textiles as they decide whether or not a discarded textile is considered waste. As such, they should be provided with the means to make an informed decision.

Providing a clear outline of what is acceptable to be donated is vital to successfully increase collection as well as reduce contamination. Some organizations would like to collect everything, so that consumer will not shy away from sorting certain textiles, by addressing the issue this may not be mandatory. It is possible to increase collection by informing the consumer that more than just wearable clothes can be donated. Not only to say that what one person may consider unwearable is not necessarily true for another, but also to imply donating household textiles. Advocating "don't throw them away" is good because it will increase collection, but it is also necessary to clearly outline what cannot be donated in order to reduce contamination. Wet clothes, clothes covered in oily substances, and clothes with distinct odors should not be donated.

A comprehensive collection bin map has far-reaching implications. By compiling all the locations of each organization's collection centers onto one map, the consumer will be able to locate the most convenient donation center or collection bin. Additionally, this map would present citizens with all their options and enable them to make a knowledgeable decision on where they would like their clothes to go.

Finally, the citizen should be educated on consuming in addition to donating. While donating textiles is important, the act of donating should not lead to increased consumption, because this will offset the environmental benefits.

Analysis of Providing Options to the Consumer

Providing options for the consumer is imperative. By having collection points provided by humanitarian organizations, municipalities, and stores such as H&M, a larger audience is captured for collection. For example, a person may not care to donate for charity reasons, so if that is his/her only option he/she will not donate at all; on the other hand, he/she may like to shop and be willing to donate if it is offered in conjunction with incentives by a clothing store. Thus, having various organizations involved in collection could increase donations as well as convenience.

Analysis of Convenience for the Citizen

Convenience was agreed to be an important factor in citizens' discarding habits. Thus, multiple options to increase convenience and subsequently increase collection were discussed. While curbside collection would be convenient for residents, it poses problems for collectors. Cost, equality, and theft were all concerns that arose during this discussion. Curbside collection was mentioned to be a better option for rural areas, while urban areas would need to explore other possibilities as providing door to door collection for urban residents would be costly and impractical as many apartments do not currently use curbside waste collection. Collecting curbside would also detract from the amount given to humanitarian organizations, unless there was an agreement between the organizations and the municipalities collecting. A suggested solution was to allow residents the choice of where their collected textiles go; this option may be a way to resolve the aforementioned issue. Lastly, the possibility of theft increases when discussing curbside collection. Therefore, ways to protect bins from theft would need to be explored in order to mitigate this issue.

Conclusion

The rise in textile consumption and waste production increases water and chemical usage, as well as CO_2 emissions, which amplifies Denmark's environmental footprint. From background research we concluded that reuse and recycling of textiles would mitigate the effects of production and consumption. The need to further explore the systems prompted us to interviews which made it possible to identify the gaps within the reuse and recycling infrastructures. This information was used to design an overall cost benefit analysis and furthermore, compiled into an informative presentation. This presentation, which outlined gaps noticed in the system, was given at a workshop attended by members of the Danish Waste Association, humanitarian organizations, and municipalities with the goal of facilitating cooperative discussion and formulating solutions.

We concluded that it is necessary for participants that handle textiles during the end of life stage to be well informed of all problems in the system so that the issues can be addressed effectively. We concluded that there needs to be cooperation between humanitarian organizations and municipalities in order to increase collection and alleviate legal issues regarding the collection of textile waste. Additionally, we concluded that there needs to be education for the public in order to widen the scope of textiles that are eligible for donation, reduce contamination, and encourage purchase of second hand textiles. Finally, there needs to be options for the consumer in order to increase convenience and expand the target audience. When addressing these factors it is necessary to draw upon the strengths of each organization to increase efficacy in the system.

Future Recommendations

During the workshop, multiple issues were elucidated which led to our formulation of future considerations for the Danish textile management system.

Convenience Solutions

There could be two strategies implemented, one for rural and one for urban settings. On a rural scale curbside collection is more feasible because it already occurs for other waste fractions due to the low population density. For urban residents, providing door-to-door collection is impractical and costly because these waste collection methods are not currently in place. Therefore, it is necessary to formulate two separate strategies that are appropriate for different systems. To incorporate different collection agencies within this curbside collection scheme citizens could be provided with the option to select the final destination of their used textiles.

Behavioral Solutions

We recommend conducting surveys on consumption and donation habits as it is the first step in addressing the behavioral issues. This will provide a better understanding of the problem and make it possible to develop effective solutions.

Educational Solutions

In order to increase collection and reduce contamination it is necessary to educate the consumer. We suggest the use of educational pamphlets as well as a comprehensive collection site map, which will allow the consumer to identify the most convenient and appropriate donating option. An example can be viewed below.

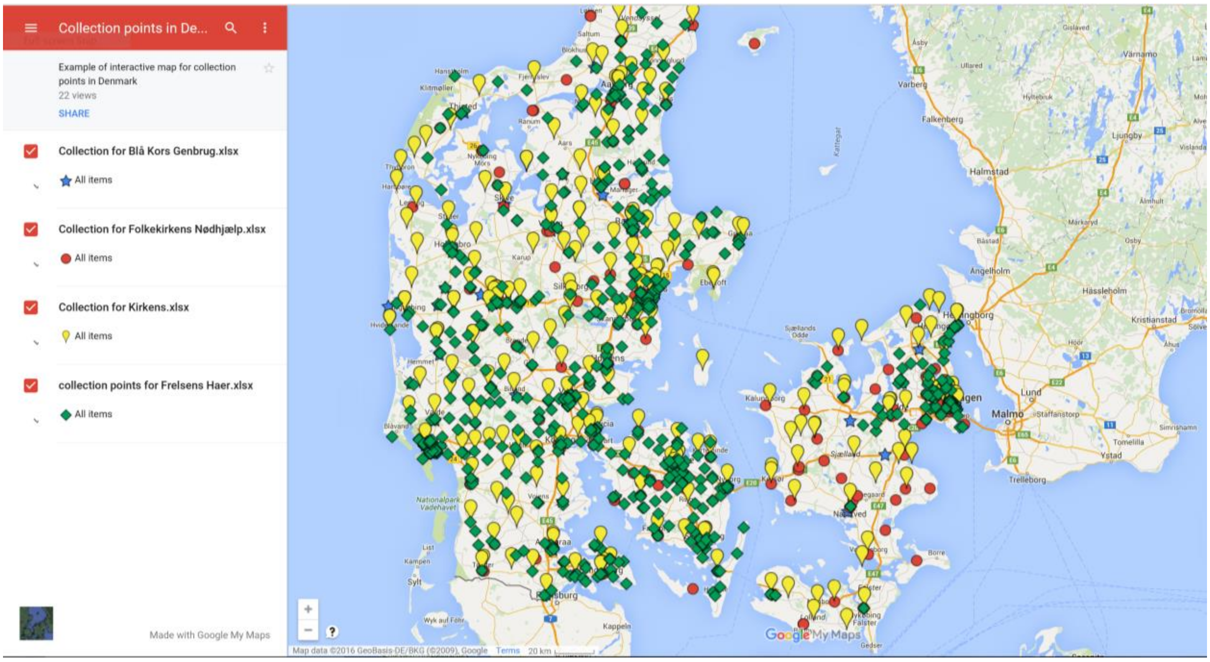

Figure 15: Collection Site Map

Legislation Changes

Changes in legislation are necessary in the future in order to remove many of the complexities surrounding this issue. Two examples of these complexities include issues with humanitarian organizations maintaining their VAT-free status as well as having to pay incineration fees. We would recommend that changes be considered as is outlined in our analysis.

Cooperation Solutions

In order for cooperation to be successful all actors involved in the textile management industry must be included. We suggest future workshops to maintain communication and continue to develop fair and impartial solutions. These workshops could provide a platform for these actors to share their progress and data regarding this waste fraction.

Appendix 1

The following prompt was used at the beginning of the interview.

Verbal Consent:

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting an interview of humanitarian organizations to learn more about textile reuse in Denmark. We strongly believe this kind of research will ultimately enhance the sustainability of textiles in Denmark.

Your participation in this interview is completely voluntary and you may withdraw at any time. This interview will take approximately one hour. If consent is given, this interview will be recorded for backup purposes. Please remember that your answers will remain confidential. No names or identifying information will appear on the questionnaires or in any of the project reports or publications unless consent is given.

This is a cooperative project between the Danish Waste Association and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study.

Proposed Questions:

1. What are your current collection strategies?
2. Who is your target audience for collection?
3. What are you current sorting strategies?
4. What is your criteria for determining whether or not a textile can be salvaged?
5. Do you send textiles to be recycled? If not, would you consider diverting textiles from the waste stream and sending them to be recycled?
6. Do you export second-hand clothes? If so, to what locations and in what quantities?
7. What are your current product destination statistics? Do you share these statistics?
    a. If so, with whom?
    b. If not, would you consider sharing these statistics
8. After discussing your collecting, sorting, and assigning strategies, what areas do you think your organization excels in?

9. After discussing your collecting, sorting, and assigning strategies, what areas do you think your organization can improve in?
10. What does your organization hope to gain from the findings of this team's project?
11. Are there any other areas you would like to discuss?
12. Do you have any questions for the team?

Closing Remark: Thank you for helping us with this project!

Appendix 2

Verbal Consent:

We are a group of students from Worcester Polytechnic Institute in Massachusetts. We are conducting an interview of municipalities to learn more about textile waste management in Denmark. We strongly believe this kind of research will ultimately enhance the sustainability of textiles in Denmark.

Your participation in this interview is completely voluntary and you may withdraw at any time. This interview will take approximately one hour. If consent is given, then this interview will be recorded for backup purposes. Please remember that your answers will remain confidential. No names or identifying information will appear on the questionnaires or in any of the project reports or publications unless consent is given.

This is a cooperative project between the Danish Waste Association and WPI, and your participation is greatly appreciated. If interested, a copy of our results can be provided at the conclusion of the study.

Proposed questions for municipalities in Denmark:

Questions for the municipalities

1. How do you collect textile waste in the municipality?
2. How much does it cost to collect the textile waste separately?
3. What are the current textile sorting and recycling methods in your facility?
4. How much man hours a year are put towards sorting textile waste?
5. What is the average salary for employees?
6. How much does it cost for sorting equipment?
7. How much does it cost to run the textile recycling operation?
8. How much textiles were recycled in 2015 (in tons)?
9. What is the demand for your recycled textile products?
10. Do you get sales from your recycled products? If so how much?
11. What is your relationship with stores and humanitarian organizations in Denmark?
12. What limitations are there in your facility that are preventing more textiles from being recycled?
13. What actions or incentives could the Danish government give to municipalities to increase the amount of textiles that are recycled?

14. Do you think these actions or incentives would motivate other municipalities to optimize reuse and recycling of textiles?
15. What actions or incentives could the Danish government give to municipalities to increase the amount of textiles that are recycled?
16. Do you think these actions or incentives would motivate other municipalities to optimize reuse and recycling of textiles?

Closing Remark: Thank you for helping us with this project!
All information obtained during an interview will be stored securely on password protected devices.

Appendix 3

Profit from 1 year with ARC-UFF type contract

$ARC = Aprice * w * t - 50 * b$

$ARC = \left(1700 \frac{DKK}{ton}\right) * 400 \frac{tons}{year} * 1\ year - 50\ bins * 1000 \frac{DKK}{bin}$

$ARC = 630{,}000\ DKK\ for\ Amager\ Resource\ Center\ after\ one\ year$

$UFF = (Uprice - Aprice) * w * t$

$UFF = \left(3000 \frac{DKK}{ton} - 1700 \frac{DKK}{ton}\right) * 400 \frac{tons}{year} * 1\ year$

$UFF = 520{,}000\ DKK\ for\ UFF\ after\ one\ year$

Curbside collection model based off of collecting 5 tons a year in a system similar to Dansk Affald

$DAprofit = w * p - b * bprice - h * lprice$

$$DAprofit = 5 \frac{tons}{year} * 3000 \frac{DKK}{ton} - \left(5\ tons * 908 \frac{bags}{ton}\right) * 0.6 \frac{DKK}{bag} - \left(1 \frac{s}{bag} * 908\ bags * \frac{1\ hr}{3600\ s}\right) * \left(110 \frac{DKK}{hr}\right)$$

$DAprofit = 12{,}137.3 \frac{DKK}{year}$

Money Available from 10% increase in collection of textiles only by the municipalities

$M = P * i * mprice$

$M = 48000 \frac{tons}{year} * 0.1 * 3000 \frac{DKK}{ton}$

$M = 14{,}400{,}000 \frac{DKK}{year}$

Money available from 10% increase in collection of textiles if municipalities sold collected textiles to collectors for 1700 DKK/ton

$M1 = P * i * mprice$

$M1 = 48000 \frac{tons}{year} * 0.1 * 1700 \frac{DKK}{ton}$

$M1 = 8{,}160{,}000\ DKK/year$

Money available from 10% increase in collection of textiles if collectors buy the newly collected textiles from the municipalities for 1700 DKK/ton

$M2 = P * i * (price - mprice)$

$$M2 = 48000\,\frac{tons}{year} * 0.1 * \frac{(3000-1700)DKK}{ton}$$

$$M2 = 6{,}240{,}000\ DKK/year$$

Water savings from 10% increase in separately collected textiles

$$WS = P * i * (pR * wR + pRe * wRe + pI * wI)$$

$$WS = 48000\,\frac{tons\ of\ textiles}{year} * 0.1 * \left(0.8 * 4527\,\frac{tons\ of\ water}{tons\ of\ textiles} + 0.15 * 53.4\,\frac{tons\ of\ water}{tons\ of\ textiles} + 0.05 * -4.603\,\frac{tons\ of\ water}{tons\ of\ textiles}\right)$$

$$WS = 126{,}876{,}457\ tons\ of\ water\ saved$$

CO_2 emission savings from 10% increase in separately collected textiles

$$CS = P * i * (pR * cR + pRe * cRe + pI * cI)$$

$$CS = 48000\,\frac{tons\ of\ textiles}{year} * 0.1 * \left(0.8 * 21\,\frac{tons\ of\ CO2\ emissions}{tons\ of\ textiles} + 0.15 * 1.3\,\frac{tons\ of\ CO2\ emissions}{tons\ of\ textiles} + 0.05 * 1\,\frac{tons\ of\ CO2\ emissions}{tons\ of\ textiles}\right)$$

$$CS = 81{,}816\ tons\ of\ CO2\ emissions\ saved$$

Appendix 4

Interview with David Watson

David Watson

dw@planmiljoe.dk

PlanMiljø – Environmental Consultancy

Spoke with at Danish Waste Association on 3/15/16

Notes:
About David Watson and his Projects

- Worked for 11-12 year in consulting
- 4 years working in textiles

Projects

- **EPR systems and new business models: Reuse and recycling of textiles in the Nordic region**
- EPR (extended producer responsibility) involves holding the producer responsible for collection and treatment of their products following end of life
    - France only country in world with a functioning obligatory EPR for textile products. Canada will soon adopt one
    - Alternative business models – include leasing, sharing, repair, resale of used own brand, clothing libraries etc.
- **Towards a Nordic textile strategy: Collection, sorting, reuse and recycling of textiles**
    - looks at existing and future collection, reuse and recycling systems in Nordic countries
    - Very little textile recycling taking place actually in the Nordic countries – is mostly exported for down cycling: Industrial rags, insulation, car upholstery stuffing etc.
    - Very little textile-textile recycling
        - No good supply of the type of textiles they need
        - Currently no way of separating mixed fibres in a mixed fibre product into the various fibres (i.e. a T-shirt made from 40% cotton and 40% polyester). The fibres can't be seprated
        - For cotton is also a quality issue – laundry processes during use and mechanical recycling shorten the fiber length and therefore need to mix with virgin cotton
        - Polyester and cotton are the "big ones"
        - Polyester can be recycled chemically, therefore virtually no limit to the number of times can be recycling
- **Towards a new Nordic textile commitment: Collection, sorting, reuse and recycling**
    - Commitment and code of conduct of the Nordic region
- **Less waste and more recycling in the textile industry (Mindre affald og mere genanvendelse i tekstilindustrien) Link**
    - Report in Danish with English summary
    - Mapping the flow of textiles in Denmark
    - New report only in Danish from 2013
    - Has more collectors for reuse in a table plus totals of different types of textile products put on the market
        - Trendsales - Secondhand websites for those interested in fashion

- **Projects still ongoing:**
    - **Fate and Impact of Used Textiles Exported from Nordic Countries**
        - Phase 1 report just finished and due to be published. Phase 2 involved detailed evaluations in Pakistan, Malawi and Poland
        - Mapped out all volumes and first and final destinations of all used textiles exported from Nordic countries
        - Once textiles are collected collectors have different approaches. Depends a lot on how they collect:
            - One does detailed sorting within Denmark, following collection via containers only (Trasborg). Sorts to over 100 different types of product. Should visit their sorting office **(contact Steen Trasborg <u>steen@trasborg.dk</u>)**
            - Red Cross and Salvation Army sort out only things they can resell in their Danish shops and the rest is sold for export. Their textiles are collected across Denmark via both containers and across the counter in their own shops
            - There's companies that only export in an unsorted state ('original')
            - E.g.UFF only collects in containers, export to umbrella corporation (Humana People to People) which has sorting facilities in Eastern Europe. All UFF textiles are collected via containers
            - "Danish social church" (Kirkens Korshær) only collect in shops and only take stuff that can be resold in Denmark. No export
        - Some do both
            - Red Cross sends to Jutland for sorting and exporting around 7/8ths
                - Limited sorting
                - Just started collecting all textiles instead of just reusable
            - Salvation army sends a lot out "in its original form", exporting to Poland
        - In all models run by these different organizations the majority ends in reuse (in Denmark or elsewhere), with much smaller amounts being recycled and incinerated.
        - This is because **all** collectors these days sell textiles at the highest price they can get in order to fund charity works (or for profit of private company). And there is much more money in reuse than recycling per tonne.
        - In other words right now the environmental benefits luckily follow the money
    - **LCA of treatment scenarios for textiles**
        - Project almost completed – report about to be published.
        - Method of looking at the entire life cycle of a product and finding its environmental impact
        - Comparing impacts (benefits) of
            - Incinerating
            - Exporting for reuse
            - Various recycling methods and substitutions – downcycling, fiber to fiber recycling etc.
        - Includes all transport up until the total end of life
        - Finds that reuse is "way better" than incineration and recycling
            - 'Substitution factor' is critical in results: we assume that every reused item substitutes a new item, but in reality

        - Depends on why the customer is buying clothing
        - Depends on who it is that is buying and their situation
      - Even down to very conservative substitution factors of just 20%, (i.e. for every 5 second hand shirts purchased, the purchase of 1 new shirt is replaced) reuse is still better than recycling or incineration!
    - Recycling (how it's currently done) is still not that much better than incineration, (though it is still better)
- Definitions of "waste"
  - When are textiles considered waste?
    - If it's been donated and can be reused, it's not waste
    - If it contains non-textile rubbish, or it is non-reusable and only recyclable it's considered to be waste
      - Legally it's owned by the municipality once it's considered waste
      - Poor definition of waste ownership could cause legal problems in the future
    - Recycling has almost no money in it, money is all in reuse
- Producers are starting to think about making products last longer
  - The market is still dominated by fast 'disposable' fashion but there are some items that people generally want to last
    - Underwear, jackets, sportswear, outdoor wear, jeans
- If we're looking for profiles of consumer behaviour, red cross has carried out consumer surveys: **contact: Ann-Christin Lystrup**

Our questions

- Commitment and code of conduct. Website: http://www.textilecommitment.org/?lang=en
- Idea of the commitment and code of conduct is that there are some untrustworthy people collecting textiles and want to limit the operations of these
  - Illegal collections
  - "gray area" collections
  - Most people discarding textiles want to know it's going to a good cause
    - There's a group of people that donate to charities for this reason
    - There's some people who'd rather get something out of donating (going to H&M, etc)
    - In any solution we need to take into account the charity needs
    - Need to find a way municipalities can help
      - Maybe as simple as allowing the charities/existing collectors to put up more collection containers
  - Most textiles are being sold to fund the charitable work, not donated to those in third world countries
  - French has signs that say that they're part of the system so people know that they're trustworthy
  - It needs to be more convenient for people to drop off their textiles
    - More information on where people can drop them off
    - Need to collect everything, not just reusable textiles
  - The code of conduct is only for collecting and sorting
    - How they should behave
    - Social goals
    - Environmental goals
    - Transparency in what happens to textiles downstream from the collection
  - Municipalities should only allow accepted trustworthy charities

        - People would be able to decide easier where it is acceptable to drop their textiles
    - Code of conduct is being tested right now
        - UFF
        - "the ant" (Myrorna) in Sweden
        - Fretex in Norway
        - Three party concept
            - Person who wants certification
            - Person who gives certification
            - Person who checks that they meet the requirements
                - At least 50% of what they collect must be reused (will be revised to 75%)
                - They must collect everything –also non-reusable textiles
                - Must follow what happens to it once they sell it (including when it's exported)
        - Swedish red cross is considering a criteria saying they will only recycle what they collect instead of reuse
            - Shows they are really worried about the bad press of potential negative impacts of textiles exported to Africa and elsewhere
                - People say reuse is ruining the textile industry in exportation areas but more likely being runined by imports of cheap new textiles from Asia under free trade agreements
        - Now called Standard for transparency and Environmental performance
    - Many more companies are following a stricter commitment
- To enforce any specific type of collection would be a mistake
    - Everyone should collect all types of textiles
    - The more that's collected, the more markets can build up
    - Develops more motivation for good solutions
- Need new technology to separate different fiber types in blended textiles for recycling
- If each municipality could generate a map of all drop sites it would be beneficial
- Approximately 12,000 out of 39,000 tonnes are being collected by NOT the top six collectors in DK
- A lot of bins are being raided
    - Maybe placement could improve this?
- Code of conduct could be a good way of moving forward
- Fashion companies are good at marketing
    - If they were on board, they could be helpful in that sense
    - Use actors strengths
- Some kind of broker between buyers and sellers could help with deciding whether or not textiles are salvageable
    - Maybe a guide on how to identify the best market for the municipalities
    - If collectors start collecting everything then citizens will be less likely to throw away recyclable or reusable textiles
    - Need some kind of "economic pull factor" - e.g. municipalities or another agency committed to purchasing all non-reusable textiles from collectors at fast price
- Personally, he finds the subject very interesting
    - They'd like to be working a lot more with the DWA because there is potential
    - Our project can be a good starting point for that

EPA: Birgitte Jørgensen Kjær bjk@MST.DK or Anne-Mette Lysemose Bendsen amlbe@mst.dk
Red Cross: about consumer profiles: Ann-Christin Lystrup, Teamleader, Commercial activities/ Dir 3525 9311/ Mobil 3160 6485; anlys@rodekors.dk. She sits in an office not far from where you live in Red Cross near the triangle
Red Cross: seeing their sorting centre in Horsens, Jutland: Claus H. Nielsen, Head of center Dir +4535259280 / Mob +4531228593 clnie@rodekors.dk
Trasborg: seeing their sorting center in Taastrup: Steen Trasborg steen@trasborg.dk
UFF: their manager in Denmark and a really nice and very informed guy: Kaj Pihl kaj@uff.dk or Nynne Nørup nynor@env.dtu.dk
Salvation Army: Kenneth_Skov-Andersen@DEN.salvationarmy.org

Appendix 5

Notes for interview at Vestforbrænding

Opening Information

- “Vist incineration”
- Started incineration in 1970
- Denmark’s largest waste company
- 550,000 tons incinerated from households and companies
- Produce electricity and district heating
- Recycling of waste from curbside collection from households
- All waste from recycling goes through trading
- Trade 332-360 tons per year
- EU legislation states that if the value is above 1.5 million DK then they have to be a public tender
- 260 employees on location and 320 elsewhere
- Purpose is not to earn money but to “break even”
    - Want to make it as inexpensive as possible for the households
- Want high recycling rates
- Board of 19 members- one per municipality
    - Generally mayors or vice mayors
- Energy department runs incineration plant
- Municipality service department offers different products to the people
    - Project management tasks
- Roughly 600 trucks a day that unload into the silo
- Food waste in one section of truck and incineration waste in another

Our questions

- Textiles have just recently been discovered as having financial value for waste companies
- Textiles are mainly a source of income for H.O.s – they are sold to the average person, not to third world countries
- Purpose of Municipalities is to keep the cost low, and to break even (non-profit). But if they were to get the income from the textiles then they would have to tell the H.O’s to leave, which would be a very big political issue.
- Have to decide to leave at it is or to implement a scheme for textiles
- At the moment they do not collect textiles curbside
    - If they decide to collect textiles, not sure if they would just keep bins at recycling centers, collect curbside, or large bulk scheme.
    - Very early stage of the project – spend a great amount of time investigating the market
    - Must know “what will make a problem later in the process” in order to get the best value
- At the moment they do not have a specific target audience
    - Established 2 second hand shops that sell furniture, books, electronics, etc. that would like to have clothes as well
    - H.O’s were hesitant to cooperate with the organization
    - Danish church aid put out clothes containers
        - 4 originally, now 6

        - There were always containers for clothes, but these were additional ones. That way they didn't have to confront anyone or cause any political issues.
        - Allowed to collect textiles, shoes, accessories, bags, purses, etc.
        - There are a large amount of second hand quality objects in the collections
            - Have different ”qualities”
                - African quality
                - China quality
                - Vintage quality
                - Roughly 20% recyclable
        - A lot of clothes can be repaired quite easily, but the average person does not consider this
- Humana has a good idea as to how much is reused, recycled, and wasted, because they have their own sorting facility in Lithuania
- Some municipalities choose which organizations to use decidedly while some do so haphazardly
- The board will try to decide what will happen for all municipalities then get approval then implement
    - Must implement what they say to implement
    - Even if they think something isn't so important to them, they still have to oblige
- If they were to have a shared collection, it would most likely be one company that would collect and trade the textiles – streamlined from Vestforbrænding
    - One "service provider"
- EU legislation – if it is an income, have to make sure that it is free competition. Ask 3, 4, or 5 contractors and get them to make a bid on the volume. Normally just one service provider.
- No sorting strategies for textiles
    - Still learning about textiles
    - Aware that they need to decide whether they will sort or if left for municipalities
    - If they decide too, when they need to make a tender they still will not know enough so it may be a couple of years until they do so
    - Need to communicate with the inhabitants that even clothes that are torn can be reused or used for recycling purposes and people may not realize that
- UFF and DTU doing research on how much incineration waste from recycling stations.
    - Around 6-8% was textiles in the incineration waste from recycling stations (what somebody will deliver at the stations)
    - Then there is waste going directly from the households to the stations from curbside collection
    - Huge potential in the incineration schemes even though there are other options because people think to just throw it out if it is torn or has a stain on it
- Nordic council made two reports within the last couple years where they describe the market in Denmark and how much is the volume in H.O.'s and it is roughly, within the municipality schemes, 100,000 tons a year where you can account for the half of it. So roughly 50,000 tons being incinerated or going elsewhere

- It is mostly what the reuse/recycling companies want, what quality, what is the value of the different qualities, and will it collapse at some point? What is the future for that?
- He thinks the board will recommend for them to start collecting textiles this year
- Government implemented a resource strategy in 2013 – stating that the recycling rate of household waste should be at least 50% by 2022. Seven focus fractions – organic waste, paper, plastic, glass, metal, wood, and cardboard. Some fractions were highlighted but not implemented and one was textiles.
- Textiles are being talked about, and many are aware of the financial aspect
- Vestforbrænding cover 1/6 of the Danish population. So if there are 100,000 tons a year, there should be 15-20,000 tons of textiles per year. If just half is possible to collect, multiply it with the value of 200-500 kroner per ton, it is a huge economy. Most waste is a cost, but this is an income, which makes it difficult to let go when one is talking about the tax payer's money.
- Danish waste is stating that that if you decide something is waste, then it is considered waste even if it still has value - definition of waste is unclear
    - Around 90% of what they collect could be reused or recycled
    - Roughly 70% is actually resold/reused – 15-20% recycled – 5% discarded
- Most companies that sort the material do it in the same way, so they have similar criteria.
- Humana has very good documentation. They have their own shops, roughly 200 shops in Lithuania and Ukraine. They have 5 week cycles for the clothes, first sold at full price, and then discount weekly. If they don't get sold in the shops then they will be sold on another market.
- Danish church aid collects at recycling stations
    - They pay the church for collection, sorting, handling, etc. – all-inclusive rate.
    - They take a small amount out for the store, the rest is sent to a collection facility
    - They deliver bins to recycling stations
    - Take to Aarhus to bring to Belgium or somewhere for sorting
- Sorted by females by throwing into holes on a table for various types of clothing
- Blue cross has sorting facilities in Denmark – not at the same extent as they do in Lithuania and Belgium and Germany.
- Red Cross has some sorting facility for presorting.
- Presorting is done for shoes and accessories, etc.
    - Pakistan does the work with shoes – will match the shoes
- This company does not actually do much with sorting, leave it up to the sorting facilities
    - Don't actually see the items going for reuse and recycling
    - Some organizations presort 30-40% just to make a better profit. But they will not do any presorting, and if they do it will be a very small amount.
    - Strategy depends on four parameters- pricing; documentation- environmental issues, and work environment; Security; and Education.
- They only trade within the EU
- 45,000 tons of indoor wood for recycling for new furniture products
- They do not make waste streams that only suit one provider because they need the security and need to make sure that if one goes down there is another option.
- To find out quality, they need to determine from multiple sites, not just one. They can only get as high recycling as the workers will allow. If they do not know so much, not

as much will be recycled. So it is about how they can set up a sorting line. Someone may have a good way to recycle sheets, while another will just consider waste.

- To find statistics, look for green statement reports
    - They do not issue reports on each fraction
    - Provide sorting results for specific fractions from curbside collection schemes
    - Don't have a problem showing what they know
    - Treat what they know with caution because they do not want to expose anyone. Some companies are in competition
- "Novel solutions" (mentioned on website) are not exactly about textiles
    - Believe in source separated waste streams, not fond of comingling
    - Looking into how they can collect different materials together, how they can blend them
        - Glass and metal
        - Paper with laminated cardboard/paper
        - Glass and plastic is an example of a bad mix because there will always be glass pieces in the plastic and it cannot be recycled
- If it's agreed upon, he thinks textiles would be collected curbside
    - This could be collected in its own category – but since things such as newspaper are decreasing, it is creating space and then one could say to throw textiles with the paper.
    - The closer that you get to the houses, the larger amount you will get of a material. It decreases when it becomes easier to throw something out as opposed to recycling
    - Textiles will be collected and sent for sorting and not returned to Vestforbrænding because they already have so much
    - Does not make financial sense to sort themselves – will be sent to subcontractor to be sorted somewhere in Europe
    - Not sure how many shops they will open, but will definitely be increasing by some amount
- Not a question if they want to recycle textiles, is a question if they want to take textiles into their own hands or leave it to the H.O.'s
- To make their money on district heating they could either open their shop, or sell to broker. They have decided to build longer pipes North and West so that they can have more customers on their own district heating
- Textiles make up less than 5% of the incineration volume
- They buy roughly 20-80,000 tons. It is easy to buy new material from the UK. Not a problem putting it in incineration, it is more of a political issue of what to do with it.
- Denmark has overcapacity of incineration – need to import waste to finance it
- Will send list of the recycling bins at the stations and who implemented them
- This project is more interesting because they are at the early stages of learning about textiles
    - Interested in how other companies do this and where they are in their findings
    - Interested in the view from "fresh eyes" on the subject

Appendix 6

Danish Waste

Jesper Vange Heinzl
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Dansk Affald – Danish Waste, provide sorting, handling, and sales of waste resources
Tingvejen 1
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Spoke with at Dansk Affald on 3/29/16

- Background Information:
    - Purchase, quality check, and sell waste
    - Owned by 2 municipalities: Haderslev and Vejen
    - Will be sold to the private sector this year
    - Core business: deal with recyclable materials
    - Textiles go into bad and then into bin (SAGA III): currently need to improve bag design
- Current collection strategies with DuoFlex
    - Just a test period with 550 homes in Vojens
    - To increase more recycling, aiming for 100% recycling/reuse
    - Bags are given to each household for free as well as DuoFlex bins
        - Bags assure quality of textiles within
        - 90% of households said they'd be willing to sort more
- Cannot handle all types of recyclable materials (construction materials, etc.)
    - Paper, cardboard, plastic, glass, metal, wood, etc. are handled
- Handle/buy waste materials from other companies and sort/do quality tests to send to be sold, be sorted more finely, etc.
    - Different partners depending on the product
- Only get textiles from households and recycling centers
- Want to cooperate with a business who does fine sorting
    - Facilities that handle larger quantities
- Export most of their products
    - In EU, but would consider elsewhere
- They check that the materials are appropriate to send to their partners but don't do specific sorting (don't decide whether the textile will be reused, recycled, or incinerated)
- No current cooperation with collectors
- Some use involves down-recycling (using old textiles as rags, etc.)
    - Making rags is no longer done by Danish Waste
- Would be interested in learning anything new regarding textiles and what we find
    - What is the best way to design the recycling of textiles?
    - Appreciate all information we can provide
    - Find the best "logistics"
        - Play to companies' strengths
- Get 3000 kroner per ton

Appendix 7

Arwos

Halfdan Neumann
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Arwos – Waste Management Facility with a Secondhand Shop, in the municipality of Aabenraa
Forsyningsvejen 2
6200 Aabenraa
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Spoke with at Arwos on 3/29/16

- 1.5 DKK per kilo of charity textiles not used in 2nd hand shops
- They get about 10 tons of clothing a year
- Separate collections for useable and recyclable textiles
- There are 20-25 second hand shops in the municipality of Aabenraas
- Arwos has two shops, one on-site and one on the German border
- Shop has a system with colored dots on the hangers to tell how long the clothes have been out for so they know when to take them out of the shop
- Thinking about collecting curbside
- Have collection system similar to Dansk Affald's Du-flex system
- Costs associated to collection of textiles would deal with purchased bags and time to sort
- Sells non-reusable textiles for Denmark to Danish Church Aid
- 1500 DKK per ton of recyclable textiles sold to DCA which is double the price for metal
- Costs them 550 DKK per ton of textiles to send them to waste-to-energy plants which is the cost for the state tax and the transportation
- Recycling creates jobs in EU
- More problems with people who don't have own bin
- Have large conveyor belt to separate paper and cardboard which is where the textiles would most likely be collected with
- Sort through 60 tons of waste a week

Appendix 8

Danish Church Aide

Background on company:

- Advocacy for poorer individuals (i.e. Africa)
- Fund this by selling clothes
- 125 Shops throughout Denmark
- Selling to Buyers in Dubai, Holland, Belgium, etc.
- Collect from both reuse/recycling stations and shops
    - Pro from station: random assortment, can be dirty or wet
    - Pro from shops: nicely cleaned out, taken the absolute best brands
- Lot of money from textiles
- Items found in DCA shops are more average
- Last year collected 700 tons, this year collected 400 tons in 3 months

Collect mainly through other companies. How do you get these? Who are you working with?

- Send their own vans out to collect
- Also put out their own containers
- Clothes that are not sold in shops like Arwos are also sent to DCA
- Arwos, Vestforbraending, Renosyd, Rynovest, Reynodrused
    - Have containers at these locations

How many municipalities contain your shops? Collection bin location?

- collection locations found online

How do you determine whether or not the textile can be reused/recycled?

- Not a decision made here
- Each shop makes a judgment call; DCA doesn't check product from containers; the buyers check

Do you have a list of the buyers available?

- Will provide the information to us
- Buyers do some sorting: by quality (Euro quality, African Quality, etc.) / season
- Some are sold in Africa or recycled (lower quality)

Do you track your product after it leaves your facility?

- There is a written agreement with the buyers that each buyer will follow the regulations of the countries they export the textiles to
- Not possible to follow a piece of clothing from start to finish due to mixing

Do you think there are any areas for improvement within your company?

- sorting: considering doing sorting. Currently shoes and clothing go in separate bags. More from a profit point of view, because if they can sell a full load of shoes they can make a lot of money.

If you had sorting here, would you try to increase collection to make it more cost effective?

- haven't decided exactly; currently do not have the facility or the volume to sort. Think it is better selling to those that already have the facility set up

What does your organization hope to gain from our project?

- Read our report
- See our strategy/ perspective
- Come to our workshop

Do you feel like there is competition in collection?

- They haven't seen the competition yet; they are new to this game
- So far everyone is benefiting; no one seems to be suffering
- There is a lot of volume, since the reuse centers are starting to focus on the need to prevent incineration

Opinion on cooperation?

- Everyone drives their van to the same places, maybe it would be better to have a huge company that collects for everyone

Is there too much overlap in collection?

- Would create a monopoly
- Difficult to control
- Would be better to have one collection facility and divide up the product

Do you benefit a lot from marketing campaigns?

- Do some campaigns with fotex; causes volume to increase
- Might just cause different people to receive the product (might reduce textiles in reuse station but increase in collection bins)
- Campaigns for other companies also benefit DCA

Municipalities could help benefit marketing, and increase reuse.

What is your opinion on curbside collection?

- Private collection needs to be sorted, so a lot of times these collected textiles still end up at DCA
- DCA received a lot of clothes from that (note: this could help increase target audience)
- Presents sorting issues (maybe educate in house sorting)

What impact with municipality curbside collection have on NGO drop off collection? Are NGOS opposed?

- Doesn't seem to be an issue; not so many people toss textiles in the normal recycling bin, generally people just store their textiles until the next time they go to the drop off center.
- Bags dropped off in containers at reuse centers are much bigger, rather than small bags that are dropped off in bins at fotex

Do you know what happens to non-reusable textiles?

- Stuffing and downcycling; done mostly in Germany and Poland

Also:

- Roughly 5-6 tons of textiles received a day
- 100 tons a month

- 4-5 DKK per kilo
- Only 30% of collected clothes from bins at shops
- They pay for textiles from reuse stations while other hum. orgs. won't out of principle

Appendix 9

Advance Nonwoven

Flemming Werk
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Advance Nonwoven – Company looking into innovative solutions for reusing materials
Moellerupvej 26
8410 Roende
+45 8779 2900
Spoke with at Advance Nonwoven on 3/31/16

- Strong at commercializing new advancements
- Established in 2006
- Goal is to sell the technology
- Use natural or recycled fibers and send through Carding – fiber matting machine to make mats that has various purposes and dimensions
- Can make the fibers fire-retardent
- They look for stakeholders who want to invest in a facility to convert waste into new products

Good information for innovative technologies and to be included in future applications of recycling textiles

Appendix 10

Renosyd

1. Sune Dowler Nygaard

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Renosyd – Waste Management Facility with Secondhand Shop
Værdicentralen
Danmarksvej 11
8660 Skanderborg
+45 22 67 22 06
Spoke with at Renosyd on 3/30/16

- Collect from Danish Church Aid
- Cooperate with them by selling clothes collected from them from containers in Sernabrough
- Opens bags and keeps good quality for store
- Gets about 18 tons a month
- Look at top to determine if bag is good or bad quality
- Has a container for clothes to go out to DCA and not used in store
- Has 5 containers
- Only take clothes to store from one container and they only take best and try to sell them and DCA does all the transportation
- 1000 DKK a ton for textiles sold to DCA
- Open 4 days a week
- 2 people try to find the best quality and one takes clothes out of cases and looks for good quality clothes and has the other put them on hangers
- Sometimes iron clothes before it goes into the shops
- Very rarely see dirty clothes
- Don't have system to know how long certain clothes have been in the shop for. The people who work there just usually know when they've been out too long
- Get new clothes two times a week
- People buy more for need and not just to buy like when they offered a price for a bag full of clothes it wasn't as successful because people may have not needed all of the clothes
- They keep it simple and it works well for selling
- DCA collects 18-20 tons a month for them
- Other charities won't pay for the collected clothes out of principle
- German company was offering them more but then they would have to set up containers and it wasn't worth the money so they stuck with DCA
- Their store's profit pays for their salaries and facilities and not the company since they are in a different department
- They reached out to other second hand shops to see if they wanted to collaborate and they didn't
- Have brochure to show second hand shops in the area
- They have the idea that it should be like car shopping where all the shops are closer so people don't have to go too far out of the way to reach multiple shops
- Market through facebook
- Shop has continued to make profit since opening

- Currently working with slogan “from trash to value”
- 11 people work there and 23 refugees work there
- Creates jobs
- Have separate streams when sorting through waste
- Sort through 15 cages a week
- Trying to change way people think from saying something is trash when it’s actually value
- Reusable items should be seen as a fraction

Appendix 11

Interview at the DTU

Anders Damgaard
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Technical University of Denmark – Supervisor of joint Uff-DTU research project about reuse and recycling of textiles
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Spoke with at DTU on 3/31/16

DTU:

- Technical institute (like WPI)
- Used to be part of Copenhagen university but split and have merged with research institutions
- Partners with UFF

Project Intro:

- For many years, textiles have not been considered for waste management. The government does not target it. Reuse is mainly privatized.
- Profit/non-profit organizations involved are quite comfortable and don't want new players in the field
- Municipalities getting involved b/c they view textiles as a revenue stream
- Increased interest due to:
    - Large environmental impacts are associated with textiles production
    - Increasing production and use of textiles
    - Increasing amounts of textile waste
- Currently there is a lack of data
- Research objectives:
    - To conduct an environmental assessment of increase collection reuse and recycling of clothes and textiles in Denmark
- The substitution rate for reuse of clothes in Denmark is lower than 1:1 and is lower than in Eastern European and African countries (behavioral studies)
- Collaborating with UFF-Humana
- Reuse phase is interesting because that option is not present for other waste fractions like paper or plastic
- From the LCA perspective, textile waste is interesting both in the reuse phase and substitution phase
- Work packages:
    - Literature review of lifecycle assessment and material flow analysis regarding reuse and recycling of textile waste in Denmark and other relevant countries
    - Determine the potential for collecting reusing and recycling clothes and textile waste in Denmark based on a MFA including a study of the quality of the materials in the flow
    - Determine the substitution rate for reuse of clothes in Denmark
    - Determine the sorting rates for reuse and recycle and waste at central textile sorting centers

- Making a LCA on collecting, reuse, recycling…. (currently on the second point)

- Mass flow analysis methodology
    - Determination of the current amounts for reuse by contact with stakeholders that handle collection of textiles for reuse and recycling (really hard to acquire this data)
    - Determination of the amount of disposed textiles for other waste management both for direct disposal and sorting residue
    - Determination of the amount and quality of textiles in small combustible waste at recycling centers via sorting trials
    - Determination of the amount and quality of textiles in residual waste from households sorting trials
    - Determination of the passive amounts of textiles at citizen's houses via questionnaires. To validate the results a number of observational studies will be combined with interviews with a number of citizens
- Sale -> consumption/stock -> use, private trade, charity, bulk waste

Assessment of amount and quality of clothes in household waste:

- Textiles as waste or suitable for reuse
- When sorting for reuse, quality criteria for destination of the textiles is considered
- About 1/3 of textiles can be directly reused with an additional 30% have potential for reuse (so roughly 64% in total)
- 11% can be directly recycled with an additional 10% could possibly be recycled
- 10% waste

Determining the replacement rate for reuse in Denmark:

- To develop a method for assessing the replacement rate of textiles for use in LCA and to determine the parameters that influence the replacement rate
- To establish the replacement rate in Denmark and compare with replacement rates in other countries
- Replacement rate: the amount of textiles that is avoided being produced when a piece of textile is reused
- Challenges:
    - Accumulation
    - Lifetime
    - Representative data
    - Method that can take into account cultural and sociological differences when comparing
- (note: that there no longer seems to be a negative impact on African economy)

Determining the sorting efficiency for reuse recycling and disposal and central sorting facilities:

- Set up a model of a modern sorting facility
- Determine the sorting rates for reuse recycling and disposal of different textiles types
- Challenge: different plants have different standards

Carry out an LCA on collection reuse, recycling and disposal of clothes and textiles waste:

- To gather all the experiences from the first 4 work packages and to carry out a general environmental assessment of reuse recycling and disposal of clothes and textile waste by using LCA
- Challenges:
    - o Data- both from the former work packages and in relation to external processes (production of clothes, efficiency in connection to sorting, reuse rate, replacement rates, and recycling of textiles)
    - o Set up realistic model
- Econet – waste sorting company they worked with
- Goals were to determine current flow of textiles in country, determine current treatment and collection of textiles
- Looked at residual waste and its effect on quality of textiles
- Did questionnaire on how many textiles households has and how much is being used
- Looked at potential of textiles that could have been used that were thrown out in bulky waste or residual waste
- Belgium has strong sorting facilities
- Danish waste estimated 5-6% of Household waste is textiles but the accepted value for Denmark is 0.6%
- Producers have 8 seasons
- 58-70% reusuable/potential reusable textiles in small combustible waste piles
- Household is about 66% potential reusable
- Textiles in residual waste is nasty because it is mixed with organic waste
- Around 40% of textiles in residual waste is clothing so more clothing ends up in residual waste instead of small combustible waste
- High uncertainty of quality assessment in residual waste
- Sweden said about 65% reusable in residual waste and about 75% in combustible waste which is similar to the results in this study

Appendix 12

ARC

Linda Rebien
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Amager Resource Center (ARC)
Kraftværksvej 31
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Spoke with at ARC on 4/4/16

- Recycling statistics account for sending resources to other destinations for treatment so higher than it should be
- 400 tons a year of textiles
- Negotiations with Rode Kors, UFF, Den Permanente, Trasborg, Folkekirkens Nodhjaelp (Danish Church Aid), frelsens Haer (salvation army) to put containers in open areas for collection instead of just recycling centers and super markets
- They want new deals with transparency about what is done with them and treated as well as an offer of price. Wanted to know reuse and recycling rates
- All companies above gave good offers and UFF had the best so they have a contract with them
- Gave price of 1725 DKK per ton and they get about 700,000 DKK a year
- 80% direct reuse
- 15% recycled
- 5% incineration
- 530 containers emptied every year with around 100 containers
- More to come
- UFF has 5 sorting plants in Europe and sort it into 25 different fractions
- Great relationship with ARC and UFF also shows high involvement with getting PhD student to do project with them to give better picture of textile flow in Denmark
- Get all clothes at recycling centers and UFF takes it and they're now starting a quarterly report with them
- Never actually see the clothes
- Have written code of conduct with UFF with labor policies
- Second hand shops becoming popular with young population
- ARC has an exchange center for all kinds of reusable materials where you can drop off stuff and pick it up for free
- Had four shops and one shop had stuff that value was so high that people fought over it
- Now they have staff and have once a week markets to better organize it
- Human. Orgs. Will come to markets and pick up stuff to sell at their shops
- View is to collect as much as possible so if curbside collection works then yes they would want to go for it

Amager Resource Center:

Presentation:

- Textile facts:
    - Most polluted industry in the world
    - Use of new textiles: 14 kg/yr/person
    - Disposal:
        - 9 kg incineration
        - 4 kg reuse
        - 1 kg in closet
    - Collection rates:
        - 46% Denmark (higher because of NGOs)
        - 20% sweden
- ARC's recycling stations:
    - Owned by 5 municipalities: dragor Frederiksberg hvidore kobenhavn tarnby
    - Arc operates:
        - 10 big recycling stations
        - 5 small recycling stations
        - 60 employees at the stations +9 administration
        - Operation budget 85 million kr/yr
    - Purpose:
        - Place where citizens and companies can dispose of waste (not residual waste)
        - Maximum recycling
        - Customer satisfaction
- Statistics on recycling stations
    - 1 million visitors a yr
    - 1 million tons of waste a year
    - Collect 33 different waste fractions
    - 89% recycle, 9% incinerate, 2% landfill, 0.3% special treatment
    - Recycling entails selling to other companies; this center does not deal with treating the materials
- ARC's textiles
    - 400 ton/yr collected (clothes and shoes)
    - Now also collecting all forms of textiles to maximize potential
    - Focus on economy. Transparency, direct reuse/recycle
    - Negotiation meetings with 6 companies:
        - Rode kors (red cross)
        - Uff
        - Den permanente
        - Trasborg
        - Folkekirkens Nodhjaelp (Danish church aide)
        - Frelsens haer (salvation army)
- ARC's contract with UFF
    - Start up in April 2016
    - Price: 1725 dkk/ton (approx. 700k dkk/yr)
    - 80% direct reuse
    - 15% recycle
    - 5% incineration
    - Bins at every station (increasing number of bins)

Side notes:

- All waste is dropped off and UFF comes and collects
- UFF provides quarterly report
- Code of conduct: focused on that
- ARC have exchange centers
- What are your views on curbside collection?
    - Collect as much as possible…if curbside increases collection then do it

Appendix 13

UFF – Humana

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UFF
Nordre Strandvej 119A
3150 Hellebæk
Spoke with at UFF office on 4/7/16

- Started with traveling high school and help started Humana – people for people
- Started off as movement of volunteers to collect clothes and other materials and UFF ran Second hand stores and flea markets to raise money for the cause
- Used to have door-door collection and then moved to collection containers. Containers since 80s
- Later UFF became Humana people to people to be more professional and well recognized around the world and second-hand clothes became business to raise funds for development projects in Africa
- Realized needed to move past volunteers and move in the direction of paid employees to make more of a business and realizing everything can't be free for everything
- Ended up having less people working but raised more money for funds in Africa
- Very long tradition to give to the poor for Nordic people even before collection containers became a thing
- Process – gives clothes to container and then sorted and either sold in Europe or Africa and then small part is recycled as raw material
- UFF formations was started from apartheid retaliation in the frontline states like Zimbabwe and Rhodesia and other countries surrounding S Africa like Mozambique
- Then Mozambique told them to stop giving them for free and instead make them pay a small price so they could do something with the economy so helps spark economy
- Only gives small amount away for disaster relief
- Big network of countries all over Europe with varying roles
- Lithuania holds one of UFF's largest sorting facilities
- 350 people work there and have capacity for 1400 tons a day
- Fine sorting for clothes that can be sold in second hand shops in Europe
- Extremely well organized shops with paid staff
- Large focus on education cause believe poor countries can't develop w/o education
- Say they do both environment aid and development aid
- Protection of environment written into their bylaws
- Hard persuading people to work in rural areas but their teachers are up to the task
- Used clothes is not waste but a valuable resource
- Used clothes is categorized as waste in EU

- Works with Nordic Council of Ministers, DTU with Nuna, DAKOFA, EPA, Municipalities HPP Baltic Sorting Center
- In Denmark it depends on intention of giving used clothes determines if its waste
- Grey areas include rubbish in containers and reusable clothes in waste
- More collection is key
- Led to them getting into collaboration with different municipalities and municipalities want to follow/get documentation of where the flow of the clothes go
- 52 containers in 9 recycling center in capitol area
- Now pay for clothes but users are informed to put all kinds of textiles into containers to get higher yield
- Still want good quality clothes but now they have recyclable qualities and increases clothes to be collected
- Has stickers on containers that state what the container is meant for which shows all types of textiles
- Has these on 5 stations and will monitor these even though only been for 2 months and will track quality for 1 year
- Still doesn't accept wet clothes cause of contamination
- Can't wash all clothes because it would not be profitable because salaried people run the company
- Volunteering important but also commercial which is very important to gain more profit for projects. Need a good balance but direction leaning more towards commercial
- Don't have too much legal issues with municipality argument on ownership of reused clothes
- Believes if it becomes completely commercial then takes away good will from cause. Still need to get clothes for free to make better profit
- Wants to keep charitable donations
- Gets around 75% reuse
- Eventually becomes waste
- Lack of space for some collection areas making it hard for some to donate in the city
- Mostly gentleman's agreement with containers at places meaning they have to move more
- Agreement with ARC gives them some rights unlike other parts
- Importance of transparency, waste hierarchy, documentations, and eventually price
- 930 containers in Denmark
- 1,600 tons from last year
- Good with documentation and degree of reuse is good because of international network for UFF
- Degree of fashion has gone up in Africa which has been a change
- Trade amongst self to get most out of material
- Red cross, salvation army, and Trasborg have large sorting in country
- Collect, bring to warehouse, ship abroad for sorting and then split up into different destinations like second hand shop in Europe, Africa, recycling, incineration
- Every step a profit is earned which gives people jobs and money

- End profit after all costs goes to development projects which is main purpose
- Charitable actors make up bulk of collectors in Nordic regions and have been doing it for years
- Certification system can be helpful to increase transparency, documentation, collection, to treat every category of the material in the best possible way and get that goal of 90% separately collected
- Separate the good guys from bad guys. Some illegal actors who want share of clothing prices and prices eventually dumped. Certification system can solve this and get collaboration with humanitarian organizations
- Once in certification system still need to track actors improvements and not be content which is helpful
- Look and say more expenses but improves systems and is good for everyone
- Helps in get more quality as well as quantity
- Test of certification has been conducted and then by September they will have model for it and hopefully go live soon
- Balance to make sure not everyone can be certified but also not too few
- Question comes to where do their obligations stop, is it from exportation to customer or when customer sells it
- Makes it harder for larger corporations to track further down the line and they want to know what is more acceptable and what’s not. As of now it’s when it gets to the sorting center and which fraction they send it to but not location
- Auditor helped UFF get better insight on what is needed to be done and makes a better quality and also an eye opener for companies
- Over year move 1 container a week
- Make it logistically wise
- Work constantly on site finding
- Helping plan how long certain containers can stay for
- Agreement with ARC and Kivi supermarkets gives them a good set of time to know how long it is there
- Paper documentation with Kivi (improving documentation last few years and don’t make sites without documentation because of demand)
- Gives public a good service if people have more choices
- People have preferences when giving away so better to give a choice
- When competitor next to them it did not affect output and more containers makes it seem more mainstream and tolerate competitors instead of arguing with them
- Agreement with ARC has only gone on for a week
- Once every quarter they will give a sorting score
- Part of agreement is ARC is putting sticker on and not UFF. Tells only what kind of materials can be in there
- Improve solution to separately collect
- Worried about clothes being stolen from illegal actors
- Definition of ownership will need to be made down the road
- Certified actors have more right to handle the textiles than other actors
- Should do better each year

- And there used to be export support for transport cost if given to africa
- Now that they pay they make sure they make right clothes make it to right places
- Municipalities need to have obligations if ownership too
- Expected quality to be lower than their quality in supermarkets for the recycling centers in ARC
- 4.5 DKK per kilo from freely collected
- 3.0 DKK per kilo from ARC, estimate
- Aarhus has divided city into three sections for collection from 3 different actors to avoid quarrels and it has been working well
- ARC took a large step in finding the correct obligations from collectors
- Ownership is being counterproductive and is only financial and not saving resources and bettering the environment
- Collaboration in Job center which is place in mainland and then they had them take their containers out and put theirs in
- Ended up creating jobs to make second hand shop and other recycling purposes but then eventually ended up having them pay for inferior products but also gave them profit with price paid while also helping that social project to help them get jobs

Appendix 14

ISOBRO

Vibeke Anderson
Isobro
Spoke with at Danish Waste Association on 4/7/16

- Care about regulation of NGO's
- Looking into more regulation into area
- Problem seen from NGO members of ISOBRO – UFF not part of organization – will be crisis with making profit with collection if municipalities play too much of a role
- Make majority of process from collecting and selling
- Red cross and Danish Church aid do lots of work outside but Salvation and red cross are also doing work within Denmark
- If recycling centers are continuing to collect and sell without giving to organizations will give them an issue
- Not against municipalities collecting but want collaboration
- Believe people should have chance to send clothes to who they want
- ISOBRO wants transparency with NGOs
- Most have condition where they don't pay anything for what they sell
- Anything they buy must be exported for these NGOs and can't be sold within country
- If buy space to have bin can they be exempt from paying tax on it and still pay municipality – future consideration
- They are looking at competition in Denmark and says they can have it with private organizations and must include costs and salaries
- NGOs have zero cost volunteers and recycling facilities do too but not because they choose but are pushed in that direction
- Believe that Recycling centers haven't thought about rules for NGOs and they are worried about unfair competition
- Currently being investigated if municipalities should be allowed to have second hand shops
- Denmark has a code of conduct for NGOs that is mandatory
- Believe municipalities should collaborate with NGOs that follow these rules
- Important for municipalities to realize CIG policies that NGOs must follow
- When municipalities enter an activity that isn't normal for a municipality then they should be selling it and showing salary for workers
- System of no salary workers will only last for a few more years so they need to understand that

Appendix 15

Trasborg Site Visit

Steen Trasborg
Steen@trasborg.dk
Trasborg
Kuldyssen 7-9
2630 Taastrup
Spoke with at Trasborg on 4/13/16

- They talk with Humanitarians frequently and share knowledge
- Don’t want or seek out conflict
- If there are too many bins in one spot, someone will lose out
  - The owner might tell everyone to leave
- The Humanitarians don’t have to pay as much as Trasborg does
  - Taxes, salaries
- Trasborg has no shops in Denmark
  - Sell outside Denmark
  - Might open shops?
    - Might be an investor for another organization
- Too much garbage in the clothes
  - People don’t care and don’t read the bins
- Market price 0.70 Euro cent per Kilo
  - Therefore, paying .20 euro cent per kilo is unattractive
- Trasborg looks for quality
- France looking for zero waste by 2020
  - Trasborg aims for 2018
- Germany does a mixture between private and NGOs
- As more people buy online, the quality in the collection bins increases
  - People buy nice things then they don’t fit right or shrink and then they donate it
- 25 girls sorting
- Drivers are independent
- Have 1570 bins
  - Used to have around 2000
- Sort every item by hand
  - Separate into categories
    - Shop quality
      - Children’s, women’s, men’s, etc.
        - Sport, summer, winter, work, etc.
  - Some sent to be turned into industrial wipes
  - Send waste to Vestforbraending
    - Pay 1DK per kilo plus 25DK in tax
- Have ways to track their drivers and where they pick up and drop off
- Takes 3-6 months to fully train a sorter
- Have problems with pressing the clothes but don’t have other options
- 45% ladies, 40% children’s, the rest men’s

Appendix 16

Anne-Mette Lysemose Bendsen
Amlbe@mst.dk
Strandgade 29
1401 København K
Spoke with at Miljøstyrelsen on 4/14/16

- EPA consultant
    - 3 years ago started focusing on textiles and sustainability at a higher level
    - 2013 new strategy in waste strategy
    - 2015 new strategy called Denmark without waste 2
    - Strategies based off of EU requirements to have waste management plan
    - Waste prevention strategy in 2015 report
    - In 2014 started in house team to incorporate all projects on textiles
    - Started a framework for textiles project to get money
    - Their framework is in Denmark without waste 2 that has waste prevention, chemical management, and third is with Nordic Counsel of Ministers that is starting different projects
    - Started well dressed campaign last spring to create more sustainably textile strategy
    - It contains 6 initiatives that they are responsible for
    - Different chemical project taking place to diminish harmful chemicals in textiles
    - Starting tag system to eco-friendly textiles
    - Recycling is limited in Nordic region and isn't economically feasible
    - Recycling mostly comes from charities collection and selling to other countries
    - They are making a stakeholder analysis to see what they can do to get a greater demand for fibers
    - Looking for grants for new environmentally friendly projects

- Giving money to advanced nonwoven
- Also giving money to Danish Waste for curbside collection
- Difficulty with reuse because it isn't considered waste so can't put regulations
- Started swap days and give money to have them set them up
- Can give money for partnerships to anyone wanting to prolong life of textile
- Business ministry is also giving grants on green growth initiatives
- Kid clothes exchange, also dress library being set up
- Minister of business and growth is starting to launch an initiative for shared economy
- Focus also on protection from harmful chemicals
- Advanced nonwoven only example for closed loop system in Denmark even though most is sent abroad when it comes to textile waste
- Also reuse of clothes gives closed loop
- Need a broader view when it comes to closed loop because of where it is produced
- Can only use soft instruments like campaigns and partnerships to deal with issues in textile waste and waste prevention
- New government stopped the establishment of partnership to prolong life of textiles
- Too early to tell if individual initiatives to increase closed loop system is feasible
- Already started most of initiatives with textiles but partnership may not happen
- Many of projects are still on going so hard to tell how effective they are so far
- They have seen so far that the small projects/events have had biggest impact so far
- Going into discussion on what the hum organizations can collect since they can't have waste and then it gets into the grey area
- Made paper for certification criteria and part of it was making sure hum organization collect all textiles which goes into waste which is controversial
- Not involved in code of conduct but following and they want to keep distance from it cause it is a voluntary system
- Every 6 months make a status update with the initiatives
- Not sure about money they will get so they have interest in getting started with the initiatives to continue getting money
- 4 million DKK for initiatives
- Difficulty with partnerships

Appendix 17

Red Cross

Tina Donnerberg
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Red Cross
Blegdamsvej 27
2100 København Ø
Spoke with at Red Cross on 4/20/16

- There are 237 shops around the country that accepts donations
- 1500 collection containers
- Economic surplus from second hand shops is what they use to make social activities in Denmark and help poor people and refugees. All surplus goes to humanitarian activities
- 8000 volunteers in the shops
- 8000 tons of textiles collected each year
    - Quality demands in the shops require higher volume since only about 6% can be used in the shops
- 1 ton of textiles each week is given away to help people
- Surplus is exported, they are very specific in keeping track of where the clothes go
    - Most is sold in eastern Europe, some is sold in Africa to microeconomic companies, a small portion is shredded
- Shops skim the textiles to look for the best, the rest is sent to 2 sorting centers in Denmark (one in Horsens, one south of Copenhagen
- They buy the bins, they are fairly expensive
    - When a bin doesn't get high volumes it is moved elsewhere
    - It is difficult to get a place to put up the bins
- Have seen that when there are a lot of bins in a line, the first bin gets the most volume
- If they purchase any clothes, they lose their VAT status
- Believe in reuse before recycling
- There are a lot of limitations from the municipalities, as the knowledge about the cost of textiles increase, the limitations increase

- Municipalities selling in their own shops creates a large issues for Red Cross
- Think that municipalities collect a lot of clothes
- Awareness in the public is very important, this is why they have started campaigning
    - This has increased the awareness, and the amount of clothes collected, not only during the campaign but it stays consistent after as well
- A lot of potential for public awareness
- They wouldn't be able to make a business if they only exported, the money comes from the shops
- The market for textiles is fluctuating a lot, especially with more and more actors in the market, not in Denmark but around the world
- Hope to double collection with the campaign, but don't think this will happen because of previous campaigns that have made consumers more aware
    - Last year the campaigns increased collection by 25%
- It is difficult to campaign two messages at once, so right now they are campaigning for increased donation, but also will be campaigning for buying reused clothes, they have made a magazine of reused clothes that will be available to the public in about a month
- A television station need to be on board, because marketing budgets are so high
- Strongly believe that recycling should increase in Denmark, especially upcycling
- Currently they have so many volunteers that a commercialized model isn't necessary
- Don't like that when they sort out the waste, they have to pay to get rid of the waste.
    - Feel that it is unfair that the people who give them the trash don't have to pay but they have to pay to get rid of it
    - Some places have decided that they will not charge them, an awareness may arise
- Definitely interested in recycling within Denmark
- Track the value chain when they export items to make sure that there is nothing going wrong in the places that they send the textiles
    - Also by adding recycling places in Denmark, more jobs would be created

Appendix 18

Convenience/Ways to increase Collection

Caroline

- Bins closer together
- More containers
- Curbside collection
  - Cost issues
  - Stealing issues
  - Textiles wouldn't go to NGOs
- Reuse needs to be easy

Charles

- Citizens need tools to increase collection through convenience i.e. Bags, maps for collection, info on types of textiles to recycle
- Have collection through a stable time period like once a week for example
- Implement system for collecting at households like curbside collection
- Give public info/education on where all collected textiles go like if its recycled, reuse, exported, or incinerated
- Possible campaigning on what collected textiles are actually used for
- Use catchy phrases, pictures, and youtube clips to get info across
- People usually think only textiles that can be sold in shops should be collected
- Needs to be increase in education of what kind of textiles can be collected

Christine

- Have more centrally located containers
- Should be put closer to the households just like they do with plastic and glass
- Look into this because younger generation doesn't go to the recycling center
- Give Consumers options by having map of bin locations
- Need to know that they can now donate rags

Leah

- Collection at the household could be viable option, but there could be a third party that collects and the citizen could specify where it goes
  - This could increase collection due to its convenience
  - Could reduce contamination
- There could be 2 systems, one for rural and one for urban

Contamination

Caroline

- Special bags and containers
  - Like Arwos?

Charles

- Special bag for bulky waste collection
- Municipalities believe that all clothes should be collected and they will handle the sorting so that consumers don't shy away from sorting certain textiles out of the bulky household waste

Christine

  - Don't believe contamination is an issue

Leah

  - Household collection could reduce contamination

Benefits shared

Caroline

- Not many ideas other than Arwos-Danish Church Aide, UFF-ARC

Charles

- Have humanitarian organizations rent collection bin space from municipalities
- Have humanitarian organizations buy collected clothes per kg but have waste fee waved

Christine

- Municipalities and EPA just want to see increased collection. If collection increases and the NGOs do not benefit, that did not seem to be an issue

Leah

- Renosyd & Danish Church Aid Cooperation
    - Humanitarian Organization Collects, gives a portion to the municipality for their second hand shop, all that is not sold is returned to the Humanitarian Organization
    - Danish Church Aid pays a price for this cooperation, but exports all collected from this site to avoid VAT issues
- Provide Options
    - Humanitarian Organizations, Municipalities, and Stores such as H&M, would appeal to all different consumers, more options more collection

H.O.s be included

Caroline

- Same as above, not many ideas for Red Cross, etc.
- Technically not legal not to charge NGOs for the waste they send to incineration

Charles

- Humanitarian organizations want to be exempt from tax from giving waste to municipalities for incineration because they receive waste from their bins so they don't think it's fair that they have to pay for it to go where it belonged all along

Christine

- Municipalities and EPA just want to see increased collection. If collection increases and the NGOs do not benefit, that did not seem to be an issue

Leah

- Don't necessarily agree with the Renosyd/Danish Church Aid Cooperation, don't like that they have chose one humanitarian organization, think its unfair (although they open the bid once yearly)
    - Could have the citizens vote on who their local municipality works with
    - The municipality could put out a bid, choose the most favorable price, then whoever decides to match this price can collect there
    - Could use this proposed code of conduct to make an educated decision about who they would like to cooperate with

Waste be defined and ownership

Caroline

- Legalities prevent collectors from collecting all textiles
    - Some kind of "fast-track" process to make certain kinds of waste allowed to be handled by non-waste management organizations
- People should pay attention to what happens to the textiles you sell to other organizations
    - Uphold a certain standard
    - Keep everyone accountable
    - Keep records of where it goes and how it's handled

Charles

- There is challenges with legislation changing
- Minister says humanitarian organizations are only given good things so it will be hard to change the legislation for eliminating incineration fees from Humanitarian waste

Christine

- Municipalities would like to see the target audience expanded to include industry

Leah
- The Consumer defines waste, many options should be available to them

VAT-free

Caroline
- Odd thing that only Nordic countries do

Charles
- Maybe could change legislation of having only volunteers in humanitarian second hand shops to give even advantage with municipality owned second hand shops
- Also second hand shops could have people come in for job training to maintain VAT-free status
- Humanitarian organizations could buy space (pay rent) for containers at municipality recycling centers to keep VAT-free status and still let municipalities get benefits

Christine
- Not addressed

Leah
- Instead of paying / kilo (and losing VAT-free status), pay a rent to the municipality, which could be the equivalent price, but would allow for collection from this municipality

Impact of exportation

Caroline
- Educate
- Start teaching them young!
    - Go to schools and do assemblies, etc.
        - Kids tell parents!
- Invite the public to come hear lectures and learn

Charles
- Second hand shops not open many hours and when they are open it is during work so it makes it hard to purchase second hand textiles
- Clothing quality declining which is becoming a bigger problem
- Produce less by increasing higher quality to increase circulation of used clothes in Denmark
- Commercialize new trends for second hand textiles to increase consumption of used textiles

Christine
- Want survey to determine consumer donation motivations
- Survey consumption habits
- Think it needs to be explored more

Leah
- Alleviates VAT if exported after being bought from municipalities

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