A product developers guide on 'better denim'

Amsterdam University of Applied Sciences

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The Implementation of Recycled Denim for the European Denim Industry.

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INTRODUCTION

As of the last decades the earth is running out of resources: humanity uses the equivalent of 1.6 earths to provide the resources we use in a year (figure 1). This means we take more from the world, than it can regenerate at the same pace (Cribb, 2017). Worldwide approximately 24.5 million metric tons of cotton are produced on a yearly base (Statista, 2016). Every kilo of this cotton consumes around 6.000 litres of water to grow (WWF, 2017). Next to this, the total cultivation of the fiber uses almost 1/4th of the world’s insecticides and 10% of all pesticides. Cotton is known for extracting more out of the soil than replenishing it, leaving the soil unfertile for food to grow (WWF, 2017).

Due to this accumulation of facts, cotton is seen more and more as an unsustainable product, and the denim industry is starting to look for alternative fibers (WWF, 2017). Cotton is, and always has been the main fiber used in the denim industry, and mainly due to this fiber jeans are perceived as an unsustainable product (Mistra Future Fashion, 2017). The negative effects of cotton production are showing; an example to be named is the drying up of the Aral Sea due to cotton irrigation (Hoskins, T. 2015).

Next to the previous stated facts, the masses of textile on landfills keeps growing. We have a textile-waste of 14 million tons a year of which less than 15 percent gets recycled, whilst nearly 100 percent of this waste is can be recycled (EPA, 2015). Todays’ linear ‘take, make, dispose’ economic model relies on large quantities of cheap, easily accessible materials and energy, and is a model that is reaching its physical limits (EllenMacArthur foundation, 2017).

It is estimated that there will be a global shortage of cellulose-based fibres of 5 million tons by the year 2020 (Re-newcell, 2017). This is due to the growing demand of an increasing number of consumers, and the strongly growing middle class (figure 2). This will stretch resources to a breaking point (Smith, K. 2014). To obtain a flow of goods, alternative routes for the extraction of raw materials need to be found. Recycling could become the foremost solution for the innovation of durable denim, as the possibilities of recycling are improving and evolving. Developing circular business models reduces the need to extract additional virgin resources from nature, and reduces the net impact on ecological resources (Lenzing, 2017). Companies are starting to show interest in recycled materials, but the supply chain is complicated and preferred quality outcomes do not seem to be there, yet.

Figure 1: ING Economics Department, 2015

Figure 2: ING Economics Department, 2015

1.1 PURPOSE
The broader relevance of this research is the assurance of a responsible continuation of denim production, as well as an education on the environmental impact of a denim, to sustain a business environment where businesses can keep on growing, but in a ‘sustainable’ manner.

The research focusses on denim because of its’ high environmental impact, and the low recycling rates of jeans (Bommel; van; Goorhuis, M. 2014). With 1.2 billion jeans sold annually worldwide (Statistical Brain, 2016) the consumption of water used in the denim industry is a big issue. Whilst water scarcity is one of today’s trending issues, the top producing countries of cotton, which are China, India and Pakistan are also the one facing with this issue (Leahy, 2015). Therefore, there is a high relevance to explore alternative routes for the production of denim jeans and fabrics (Mesfin M.; Hoekstra, Y. 2016).

The goal of the research is to make it possible for denim brands to start creating denim from recycled materials, and thus start thinking in a circular economic way. The research will inform denim brands (denim designers and product developers) about the impact of their production, and it explains how to integrate recycled cotton into their denim range in the best possible way without losing quality or without paying a higher price.

1.2 PRODUCT
The product created with the input of this research is an educational folder first and foremost specified for Tommy Hilfiger, but relevant to all denim brands located in Europe. This report is supported by a denim sample developed under my lead, consisting of post-consumer recycled materials, and washed in a sustainable manner, showcasing the difference in environmental impact compared to a conventional produced denim. The research and product are able to inform companies about the relevance and future of recycling denim. It advises companies on how to integrate recycled cotton and how to start using a circular production cycle by clarifying the supply chain of denim recycling.

1.3 STRUCTURE
This report starts with an explanation of the circular economy, which is the driving economic model behind the recycling of denim. Continuing on this, you can read an analysis of the problem, which is the impact of conventional cotton and the denim industry on the environment. The following chapter clarifies all different stages of the supply chain of recycling cotton, and explains the difference in impact of recycled cotton compared to conventional. The chapter following this includes an overview of case studies and challenges and opportunities of the recycling of denim products. The final chapter concludes the findings of the report.

I got to a final conclusion by answering the following main question: “How can the denim industry implement the circular economy, and to which extent can this improve the sustainability?”

Sub-questions:
1. What is the philosophy of the circular economy, and what does this mean for the denim industry?
2. What is the environmental impact of the denim industry and conventional cotton?
3. What are the steps of the supply chain of recycling denim?
4. What are the challenges and opportunities of recycling denim for the European denim industry?

1.4 METHODOLOGY
The research consists out of secondary data from articles and reports from newspapers, journals, case studies, books and websites from both governmental organizations and non-governmental organizational (NGO’s), like the WWF, Ellen MacArthur foundation, Circle Economy and the Footprint Network.

Primary data is retrieved from several interviews and meetings with fabric and yarn suppliers who supply recycled fabrics (ORFA, Ryo and Candiani), with companies and brands who use recycled materials (Kings Of Indigo and Tommy Hilfiger) and with spokespeople from the industry focusing on responsible innovation (REMO and Circle Economy).

During the duration of the research, information has been obtained by attending two renowned denim fairs: the Kingpins in Amsterdam and the Denim Premiere Vision in Paris. And in addition, the recycle facility Texereum in the Netherlands, and a denim manufacturer, Demco in Tunisia were visited to gain first-hand information.

During my research I collaborated with the product development team of Tommy Hilfiger Menswear Denim, the Corporate Responsibility team of PVH and the Denim Alliance, an organization subsidized by the Dutch government, which has as goal to unite 11 brands, so they can create and buy a post-consumer recycled fabric together. Prior to my research, I gained a lot of information and knowhow on the topic of recycled denim during my previous internship at sustainable jeans-brand Kings of Indigo.
2. What is the philosophy of the circular economy, and what does this mean for the denim industry?

The philosophy of the circular economy is to create an economy in which today’s goods and products serve as tomorrow’s resources, forming a virtuous cycle that nurtures prosperity in a world of endless resources (EllenMcArthur Foundation, 2013). The model is inspired by the biological processes of nature, where dying flora and fauna are a source of nutrition for others (Circle Economy, 2017).

Recycling is the most critical point in this new economic system, which will be researched and explained in this report. The circular economy has been applied to and has become an intrinsic part of our everyday language for sectors like glass, plastic and paper. Yet while recycling continues to grow, there is still one industry slow to embark: namely the textiles and apparel industry. For this industry the creating of a circular system is very much seen as a challenge (Nguyen, Stuchtey and Zils, 2014).

High Value or textile-to-textile recycling enables textile ‘waste’ or garments to be redirected back into the textiles-loop as recycled raw materials. Garments can either be down-cycled (intro products with a lesser value), re-used, repaired, up-cycled (into products of a higher value) or completely recycled. But textile ‘waste’ streams remain throughout the supply chain currently still a large untapped resource. This is due to the lack of established technologies, processes and business models to redirect these fibres back into the supply chain (Smits, Cunningham and Spathas, 2016). A complete circular system is not yet possible for the denim industry, but new technologies are under development which will help the start of circular systems and open-loop recycling. The fashion industry is showing more and more interest in the idea of circular production, if not for the environment, then for the cost saving side of it.

3. What is the environmental impact of cotton and the denim industry?

3.1 ENVIRONMENTAL IMPACTS OF COTTON

Cotton is the most widespread profitable non-food crop in the world. Its production provides income for more than 250 million people worldwide and employs almost 7 percent of all labour in developing countries (WWF, 2017). Cotton accounts for 32 percent of all fibres used across the globe, second biggest after polyester, which accounts for over 60 percent. Cotton is grown in over 80 countries, and takes up 2.5 percent of the world’s farmable land. However, close to a third of the world’s arable land has already been lost due to soil erosion and pollution from the amount of chemicals and pesticides used to grow conventional cotton and other crops, the urgency to end the industry’s dependence on cotton is plainly evident (Hendriksz, V. 2016).

Cotton is also being referred to as white gold since it remains a central resource in nearly all of the fashion industry’s sectors, from denim to jersey and for some countries, like Uzbekistan, it is their main export good. But then again, the fiber is often cited as one of the thirstiest crops, it is one of the most water and labour intensive crops to grow. Results of this can be seen in Uzbekistan’s Aral sea, which has dried out due to over-irrigation of cotton-fields (Hoskins, T. 2015).

According to a life cycle assessment (LCA) conducted by Cotton Incorporated (2013) the primary environmental and energy impacts for the cotton agriculture phase are due to fertilizer production (nitrogen), irrigation, and post-harvest (ginning).

According to Cotton Inc. (2016) to grow only 1 kilogram of cotton, it takes the following environmental factors:

- 6000 Liters of water (1140 showers)
- 8 kWh of Energy (44 laundries)
- 1.81 kg of CO₂ equivalent (driving 17 km by car)
- 2 grams of chemicals.
- Eutrophication potential 38 gram EP: Due to fertilizers, waterways get excessive amounts of nutrients, which induces growth of plants and algae which can result in oxygen depletion of the waterways and its fauna.
- Acidification potential of 18.7 gram AP: is the ongoing decrease in the pH of the Earth’s land and ocean, caused by the uptake of carbon dioxide (CO₂) from the atmosphere (and causes acid-rain) (Rockström, J. 2015)
- 10 m² of land-used which is not available for food
3.2 ENVIRONMENTAL IMPACTS OF THE DENIM INDUSTRY

Denim is one of the powerhouse in fashion with its market size of €54.5 billion in sales per year. Each year around 1.2 billion pairs of jeans are produced and sold worldwide (Statistic Brain, 2016). Despite the economic recession, the demand for denim products has continued to rise several percent annually all over Europe (CBI, 2016). However, denim is also one of the most impactful categories in the industry in terms of environmental and human costs. The production of denim uses great amounts of water and chemicals. From growing the cotton, to processing, dyeing, finishing, shipping and once at the customer stage, with home-laundry. Over its lifetime, a pair of jeans consumes on average 10,850 litres of water and contains 32.5kg of CO2 emissions according to the jeans consumes on average 10,850 litres of water dyeing, finishing, shipping and once at the customer stage, with home-laundry. Over its lifetime, a pair of jeans consumes on average 10,850 litres of water and contains 32.5kg of CO2 emissions according to the growing volume of post-consumer textile waste, for example, the growth in disposable clothing, the impact of the fast fashion industry, and the increasing consumer waste these resources are saved from being used by multiple companies nowadays, but still in its development phase. Mechanical recycling is being used by multiple companies nowadays, but this technology has its limitations. When recycling mechanically, fabrics are shredded in pieces, and torn apart until the parts are fiberized. This process breaks the length of the fibres, so the output is always less valuable than in its virgin equivalent. With chemical recycling this problem might be rectified.

When explaining the steps followed during the process of bringing denim in the circular economy we need to separate three kinds of cotton waste: industrial-, pre-consumer and post-consumer cotton waste. The industrial waste can come from both the spinning mill and the manufacturer. The pre-consumer cotton waste comes from finished product that never reached the customer, so can either be damaged or unsold stock. And the most impactful, but also most difficult waste-stream to recycle is post-consumer waste. Under post-consumer waste we understand products which have been worn-out or which are simply just discarded by the consumer. When recycling post-consumer waste these resources are saved from being used by multiple companies nowadays, but still in its development phase. Mechanical recycling is being used by multiple companies nowadays, but this technology has its limitations. When recycling mechanically, fabrics are shredded in pieces, and torn apart until the parts are fiberized. This process breaks the length of the fibres, so the output is always less valuable than in its virgin equivalent. With chemical recycling this problem might be rectified.

4.1 TYPES OF COTTON WASTE

4.1.1 INDUSTRIAL WASTE

The biggest part of industrial waste comes from cutting waste which is generated at the manufacturer during the cutting process of the denim patterns. Factories have a target of using 80 percent of the fabric when cutting the patterns, but this can differ per pattern, generally the percentage is less with the cutting of women’s denim, due to the fact that these patterns are more curved (Meirsma, de J. 2017). Usually this 20 percent cutting waste is being d序循环 by third parties for the product of non-wovens, which serve as fillings for mattresses, cars, houses etc. Industrial waste is the most qualitative and easiest waste-stream to recycle, due to the clarity of the material.

4.1.2 PRE-CONSUMER

Pre-consumer waste are ready made products that cannot be sold and are therefore seen as waste. This can either be stock which is damaged, out of style, overproduced or returned items which cannot be resold. According to a report of the Circle Economy (2016) it is estimated that up to 33% of garments that are produced, are never sold and are in many cases destroyed to avoid flooding the market.

4.1.3 POST-CONSUMER

The impact of the growing textiles industry, combined with fast fashion models can be seen in the ever growing volume of post-consumer textile waste, for which there are still limited end-of-life solutions, since the collection of this waste-steam is not centralized, the collected items are very diverse and the quality is often very low. In the EU and US alone, 20 million tonnes of textiles end up in landfill or incineration every year. Roughly calculated, 5 percent of our landfills exist out of textile-waste (Smits, Cunningham and Spathas, 2016).

4.2 RECYCLING SUPPLY CHAIN

The usual textile recycling chain includes: collection, sorting, sales re-wearable clothes, processing non re-wearable clothes and textiles, mechanical recycling or chemical recycling, and processing the outcome back into fibres, yarns and fabrics.

4.2.1 COLLECTION

The collection of post-consumer textile waste is organized by numerous commercial and charity organizations. recollect, Reshare (Salvation Army) and Sympany are of few of biggest collectors, also operating in The Netherlands. These organizations sell the collected clothes to sorting companies. In the Netherlands, approximately 80,000 tonnes of clothing is collected in this way (while at least another 140,000 tonnes is not collected) (Bos, P. 2016).

4.2.2 SORTING

Clothing sorting companies examine the quality of the materials collected and separate them in several categories of wearable clothing and other fractions of non-wearable materials. Currently this is still all done by hand. The garments may end up with 200 different fractions of sorted textiles, sorted by colour, composition, and product group. The non-re-wearable clothing is sold to thrift shops (small percentage) and to countries in Eastern Europe, Asia (India, Pakistan, Bangladesh) and Africa. The non-re-wearable clothing is mainly processed into products such as cleaning cloths, sponges, blankets and insulation materials (Texperium, 2017).

4.2.3 RECYCLING

When recycling cotton waste or post-consumer denim there are three options to choose from: mechanical, chemical or bio-chemical recycling. Mechanical recycling has been on the market for a longer time then chemical recycling, and is productive on industrial scale, whereas chemical recycling is mainly still in its development phase. Mechanical recycling is being used by multiple companies nowadays, but this technology has its limitations. When recycling mechanically, fabrics are shredded in pieces, and torn apart until the parts are fiberized. This process breaks the length of the fibres, so the output is always less valuable than in its virgin equivalent. With chemical recycling this problem might be rectified.

There are strict rules and regulations about the releasing of the water used in the dying and laundry process back into the environment, but this is not lived by everywhere due to the costs it takes to clean the water.
4.2.4 MECHANICAL RECYCLING

When recycling denims mechanically there are three options: (1) incineration, to generate energy; (2) down-cycling, to create nonwovens, like insulations; and (3) High value recycling, to create a yarn for the production of new garments. The research focusses on the last option.

To recycle denims from textile-to-textile (high value recycling) the fabric has to be fiberized. In such a process, the fabric is completely unravelled again until only fibres remain. The zippers, buttons and other non-textile components can either be removed mechanically or are cut off at the begin stage. Most recycle facilities can only recycle 3/4th of the denim, and cut the top part containing all the metals and the leather patch off. The textile input goes through different fiberization stages, starting its process by being shredded into pieces, before entering the fiberization machines. These machines push the textile through rollers with big and small hooks. This step repeats itself 3 to 5 times, but every step the hooks on the machinery are smaller. The hooks pull the fibres apart from each other, until only fibres are left. The challenge here is, when the process is repeated too often, the fibres are cut too small, and cannot be made into yarns again. But when the process is not repeated often enough, the output will still contain pieces of yarn.

4.2.5 CHEMICAL RECYCLING

Denim products made from blended materials account for a high proportion of the market today. And yet no commercially viable separation, sorting, and recycling technologies are available for many of the most popular materials, such as cotton and polyester blends (H&M Foundation, 2016). Due to the limitations of mechanical recycling, high hopes lie at the rise of chemical recycling. Chemical recycling is a new technology which addresses major barriers in textile-to-textile recycling, namely: how to separate blended fibre garments; and how to separate dyes and other contaminants from polyester and cellulose (Kering, 2017).

Chemical recycling could be the missing link in the creation of a circular economy for the denim industry, the technology would enable genuine circular recycling, by producing virgin equivalent outputs from textile waste (Rhoades, C. 2016). Many companies are investing in research and development, and chemical recycling has proven to be valid on laboratory scale. But investments are needed to put these processes into work on industrial scale.

The British company Worn Again is developing a technology that can separate and recapture the raw polyester and cotton materials from textiles which can then go back into the supply chain as new.

4.2.6 BIO-CHEMICAL RECYCLING

Cellulosic recycling, also called bio-chemical recycling is at its developmental stage, with R&D projects at: Re:newcell, Lenzing, Evrnu, Ioncell-F (winner of the global change awards 2016), Manchester University, and Saxion University. All projects are aiming to recycle both industrial and post-consumer cotton waste into either chemically modified (viscose) or pure cellulosic (lyocell) fibres. These projects are based on the pulping of the cotton and its dissolution in solvents associated with these fibres. The processes are non-toxic and environmentally friendly (Aalto University, 2016). The industries’ leading cellulosic fibres supplier Lenzing recently launched a Tencell lyocell fiber consisting out of 20 percent recycled cotton, this is a premier in the usage of recycled cotton as cellulosic fiber on industrial scale (Lenzing, 2017). The production of such cellulosic fibers is almost completely circular, since the water and solvent used, can be recycled over, and over again.

4.3 IMPACTS OF RECYCLED COTTON VERSUS VIRGIN COTTON.

When recycling cotton the whole process of the cultivation of the fiber is omitted. This means there is no impact from land use, irrigation, fertilizers, insecticides or the harvesting of the crop. Also the social misconducts related to cotton cultivation are avoided this way. But the biggest impact of growing cotton, the use of water during the irrigation, is completely cut from the process, since there is no water needed in the recycling of cotton.

Unlike water, energy and CO₂ contribute less to the footprint of cotton cultivation. CO₂ is emitted and energy is required for the pre-processing of textiles for recycling. Instead of cultivation and harvesting of the virgin crop, the recycled fiber needs to be collected, transported and processed back into fibres. All factors which need to be taken into account when comparing the energy input. But as long as renewable energy would be used in the process, this should not be an issue.

Recycled cotton avoids greenhouse gas emissions from cultivation, such as the use and production of fertilizers and pesticides. According to a case study executed by G-star Raw and the Circle Economy (2016), in comparison with the CO₂ emitted during the process of recycling (collection, transport and processing) the emitted CO₂ is still reduces by 30 percent for the percentage of recycled fiber in the fabric.

In this same case study the Circle Economy states that for the percentage of consumed energy can be reduced by 35 percent for the percentage of recycled cotton compared to the virgin cotton. But spinning and weaving are the highest contributors to energy consumption in the process of producing a denim fabric. Both of which are not avoided with the recycling of cotton.

Put in statistics this means that if one kilogram of conventional cotton denims were to be reused instead of produced from conventional virgin sources, it would save 3,6 kg carbon dioxide, 6000 litres of water and 0,3 kg of fertilizing chemicals and 0,2 kg of insecticides (Re:newcell, 2017; REMO, 2016). Additionally, around 10 M² of arable land is saved from the production of cotton, and can for example, be used for the production of food instead (Cotton Inc. 2016).
5. What are the challenges and opportunities of recycling denim for the European denim industry?

5.1 CURRENT CASE STUDIES
The below displayed case-studies represent the success stories of the implementation of recycled cotton thus far. On commercial scale the implemented percentages of recycled cotton are still relatively small, since all below named brands have high standards for their offered quality. More successful results and higher percentages are shown on developments and prototype scale, but have not been released on the market yet.

5.1.1 Levi Strauss x Evrnu
In 2013 Levi Strauss teamed up with EKOCYCLE to produce a limited edition of the 501® WasteLess jean. This style was produced with a content of 29% post-consumer recycled material, of which 20 percent mechanically recycled cotton and 8 percent recycled PET plastic bottles (Levi Strauss, 2013).

Next to this initiative, Levi Strauss teamed up with bio-chemical recycling company Evrnu in 2016. Evrnu is a Seattle-based start-up that reconstitutes old fibres into new with its’ patent-pending technology, which breaks down cotton till a molecular level before extruding the resulting pulp into new fibres. The companies together created the first jeans made up of more than 50 percent post-consumer cotton waste (Ecoutterre, 2017). A prototype of Levi’s 511s was created, using a mix of virgin cotton and five old cotton T-shirts. Evrnu states their system consumes 98 percent less water than those associated with virgin-cotton products (Evrnu, 2017). These jeans could be a reference for a future where textiles are regenerated not just one time, but which can be recycled multiple times before going to waste.

5.1.2 G-star x Circle Economy x Recover
Next to G-star’s widespread “RAW for the oceans” campaign, using 20 percent recycled bionic yarn made from collected plastic ‘from the ocean’, G-star is also working together with the Circle Economy to close the loop on their denim ‘waste’ stream (Bruinsma, 2016). The companies together created a Life Cycle Assessment (LCA) on the impact of the recycling of G-star’s returned stock (pre-consumer waste).

The goal of the project was to create new denim fabric that could compete with virgin cotton denim on price, quality and aesthetics, but then with a lower environmental impact. At recycle facility Recover in Spain, G-star developed a yarn containing 30% recycled cotton, which was the maximum quantity in order for it to retain the needed strength for weaving and finishing. With this yarn only applied in the weft, the total denim consisted out of 12% recycled cotton (Circle Economy, 2016a).

The result of the LCA showed that even with only 12% recycled cotton in the denim, the use of water would be cut with 8,837 m3 litres on the total produced fabric (9.8 percent). The energy consumption reduced with 4.2 % (for the 12 % of recycled fiber this went down by 35%) and the emitted CO2 went down 3.8 % (for the recycled fiber this percentage was 30%). But other than the positive effects the pilot showed on environmental impact, the cotton did have a price premium of 12.5 % compared to conventional cotton, which made the project less attractive for G-Star to continue (Bruinsma, 2016b).

5.1.3 Kings Of Indigo x Royo
In 2015 Denim City initiated a collaboration between Sympamy and Kings Of Indigo. Sympamy, a Dutch textile collection company collected worn-out denims worn in Amsterdam, and shipped them to recycling company Recover. Together with Spanish denim mill Royo, Kings Of Indigo created a fabric consisting out of 19% post-consumer recycled cotton, and 81% organic cotton. According to the makers, this was the first commercial collection containing such a ‘high’ percentage of post-consumer recycled cotton (Fashion United, 2015).

Even though the techniques have been available for a longer time, the collection and recycling process had not been profitable before by individual companies. In 2016 the second line of this project launched with a percentage of 21% post consumer recycled cotton, 7% hemp and 72% organic cotton. Kings Of Indigo keeps working on improving the percentage of recycled content in their Red Light Denim line (Kings Of Indigo, 2016).

This line also collaborates with REMO, who made a track and trace system to show the customer a transparent supply chain. By scanning the REMO QR tag, the customer is informed about the percentage of recycled material, where this material comes from, and the savings in environmental impact (the Denim Daily, 2015). The tag shows that the Red Light Denim saves 1755 litres of water per kilogram of fabric, 0.57 kg of CO2, that is not emitted, and consumes 8.2 kwh less than regular denim (Fransen, L. 2015).

5.1.4 Mud jeans x Recover
Mud jeans is a Dutch denim company with an innovative lease-a-jeans concept which they launched in 2013. Anyone can lease a jean for a monthly fee, after use the customers can send their used jeans back and switch them for a new model. Over the period of 2013-2016 more than 5.000 customers have returned their jeans to the brand. Of these 5.000, 2.000 have been upcycled, and have been put up for sale as vintage offers (MVO Nederland, 2016).

The other 3.000 the brand brought to recycle facility Recover, where the jeans were recycled back to the fibres in order to make new pairs of jeans. Mud jeans designs its jeans with recyclable back patches, which ensure that also the top part of the denim can be recycled. Once at recover, the denims were shredded into fibres and accordingly spun into yarns, dyed and mixed with new cotton. The new material is made up of 20 percent recycled material, which is for MUD the highest percentage possible in order to keep their quality assurance. MUD Jeans defines itself as the “first and only denim brand that can genuinely be called circular” (Mud jeans, 2017).
5.1.5 Denim Alliance x Circle Economy

The Alliance for Responsible Denim (ARD) is a project running from 2016 till 2018, set up by the Circle Economy, House of Denim and the Amsterdam University of Applied Sciences. The project is set up with the intention to improve the use of post-consumer recycled denim in the denim industry. Nowadays the supply chain of recycled denim is very complex, the investment costs are high and the quality output lower as the virgin equivalent of recycled cotton. By establishing a preferred buying standard, the volume of post-consumer recycled denim can rise, which can reduce the costs and this can help its adoption in the industry.

The project brings 11 leading denim companies together, amongst whom: G-star Raw, Nudie jeans, Denham, Kings Of Indigo, Just brands and American Today. By combining their knowledge, buying power and resources, the industry can be more effective in addressing the problem concerning recycling. The project is still in its research phase, where all brands share their knowledge and input for their preferred solutions. For the best result the recycled fibres are by adding either polyester or RPET (recycled plastic) to denim in the yarn and fabric the more the strength is increased of using recycled materials is often not seen (Mathews, 8, 2017). Lastly, the balance of supply and demand is causing a slow development of recycled fabrics. Brands fail to embrace supplier initiatives, because the importance of using recycled materials is often not seen (Mathews, 8, 2017). These high prices need to be conquered by scale. High demands would assure lower prices. And to get to a higher demand the importance of the environmental impact needs to be shown and known to both suppliers and brands. Therefore education on this topic is an important aspect.

5.3 OPPORTUNITIES

Due to the limitations of mechanical recycling, high hopes lie at the rise of mechanical recycling. Expected is that recycled cotton will play an increasingly important role in the years to come, while further technical innovation will be needed to increase recycling possibilities and improve the recycled fiber quality (H&M Conscious Actions Report, 2015)

Chemical recycling addresses how to separate blended fibers, and how to separate dyes and other contaminants from polyester and cellulose, the developments on this topic are currently still on laboratory scale (Kering, 2017). To scale up the technologies of chemical and bio-chemical recycling to a large scale will be the future. But the need for this is missing out on business this way.
Another big opportunity for the recycling of denim is cellulose recycling. This trending topic is being developed by multiple companies and universities. The breakthroughs in these projects brings us one step closer to a new textile industry where “waste” is a viable new crop we harvest to create new garments from (Evrnu, 2017). Austrian cellulose-fiber company Lenzing is the first to bring a Tencel lyocell fiber to the market made with 20 percent recycled cotton waste. Their fiber, called ‘Refibra’ is made from industrial cotton waste, mixed with the standard input for Tencel, which is Eucalyptus pulp (Lenzing, 2017).

The recycling of industrial cotton waste is less time-consuming than the recycling of post-consumer cotton waste, since industrial cotton waste does not include dyes and chemicals. Finnish Aalto University developed ‘Ioncell-F’, which technology includes an appropriate pre-treatment process for the use of post-consumer cotton, by dissolving dyes and chemicals from the textile before it is entering the recycling process. The technology won the Global Change Awards 2016, initiated by the H&M Foundation. With this prize the group won a subsidy of 300,000 euros, which is dedicated to the continuation of the research on the process. The fibres produced by the Ioncell-F process are equivalent in characteristics to virgin cotton fibres of highest quality. Similar to this technology is SaXcell, which is developed by the Dutch University Saxion. The process proved itself with the production of 50kg of cellulosic fiber. And the research group is looking to set up a pilot plant to assess the feasibility of the technology (Brouwhuis, 2016). The pilot plant would enable more research and fine-tuning of the production process, and new forms of SaXcell could be developed. The fibre structure can be guided and the characteristics of the fibre can be influenced, which makes the fiber suitable for different product groups (Saxion, 2016).

Additionally to the above named technologies, the most promising cellulose recycling company presently is the Swedish company, Re:Newcell. The company has invested 8 million euro in the construction of a textile recycling factory, which is estimated to be completed by the third quarter of 2017 and have a maximum capacity of recycling 7,000 tons of post-consumer cotton-waste a year (McGregor, 2017; Horvath, 2017). The outcome is a high qualitative cellulose fiber like viscose or lyocell. The characteristics of this fiber can give a soft and silky effect when used in the production of denim. The only limitation here is then that a denim created from 100 percent recycled cellulose fiber will not have the outlook and hand-feel of a rigid masculine denim fabric, which is in many cases preferred.

The expected growth of the middle class, population and standard of living will drastically increase the demand for textiles, while an increase of cotton production is difficult to achieve on account of the agricultural land required for farming and the amount of water required for irrigation (International Cotton Advisory Committee, 2015). The recycling of denim is therefore not only a choice for a “better” or “more fair” way of producing, but in the near future it is going to be a critical need to keep existing materials in the supply chain.

At the present time a complete circular system for the denim industry is not possible thus far, since waste cannot be fully eliminated, as well as that an industrial scale a denim made from 100 percent recycled cotton is not executable yet, neither by recycling mechanical or chemical. But awareness around sustainability is growing rapidly, and the traditional “take, make dispose” model is being looked at critically. Steps are being made in the direction of setting up circular systems, and open-loop recycling is being implemented. This starts with the creation of a circular mindset for brands during the design, development and waste-collection process. The number of developments and innovations in a circular economy are increasing. The recycling of cotton, will play an increasingly important role in the present-day and years to come. But further technical innovation will be needed to increase recycling possibilities and to improve the recycled fiber quality.

The research has shown that there are a number of limitations when it comes to mechanical recycling. The possibility of recycling traditionally mechanically recycled cotton to a qualitative denim is relatively low; however, even a small percentage of recycled material in a denim fabric has a positive effect on the environmental impact of a denim. When recycling cotton the whole process of the cultivation of the fiber is omitted, which saves precious resources. This means there is no impact from land use, irrigation, fertilizers, insecticides or the harvesting of the crop. Also the social misconducts related to cotton cultivation are avoided this way, and a new industry and job opportunities are created on the other hand. But the biggest impact of growing cotton, the use of water during the irrigation, is completely cut from the process, since there is no water needed in the recycling of cotton.

Denim recycling can be subdivided into mechanical-, chemical- and bio-chemical recycling. The output of (bio) chemical recycling allows the fiber output to go back into the system in an equal quality as the input, whereas mechanical recycling breaks the fiber strength down. However, mechanical recycling methods are already playing a crucial role offering “textile to textile” recycling on industrial level, whilst chemical recycling only has proven to work on small scale. Denim mills have been producing yarns containing mechanically recycled denim obtained from pre- and post-consumer garments for a few years already, and fabrics up to 25 percent post-consumer recycled denim are available on the market. So we can conclude that “high-value recycling” of denim to denim is possible. Yet, the quality of the mechanical recycled denim does not have the same strength and consistency as conventional produced denim (Smits, Cunningham and Spathas, 2016). Nonetheless, game changing chemical technologies are on the horizon and are expected to provide the scale that is needed to generate a tipping point in creating a circular system for the denim industry (Circle Economy, 2016).

When combining the different recycling technologies, higher percentages of recycled fiber can be implemented. In theory, the realization of a denim garment created from 100 percent post-consumer waste is possible if the output of bio-chemical recycling, mechanical recycling and recycled plastic (PET) would be combined. The cellulosic recycling, is the most promising technology for the denim industry to get fully circular. The execution of this technique will be operational in the coming three to five years (Re:Newcell, 2017). For companies to be ready for this break-through it is important they start: educating themselves on this topic, designing for a circular supply chain and identifying their waste.

Overall, to set up a circular system, more education on the importance of the topic is needed. When both businesses and consumers have a better awareness and understanding on this topic, waste can be collected in a better and more centralized manner. A more effective waste-collection-system would mean more opportunities for high-value textile to textile recycling.

Above more, collaboration between the different stakeholders is fundamental. There are numerous organizations and brands working on the topic of creating circular systems for the denim industry, with the aim to reduce garments going to waste and landfills. But solutions are now being sought independently and experience and knowledge are not or limited being exchanged (Go den Brouw and Wergroep, “Circulaire Economie, 2015”). By combining knowledge, investments, buying power and resources, the industry can be more effective in addressing the problem concerning.
7. BIBLIOGRAPHY


CBi - Ministry of Foreign Affairs (2016). Exporting denim to the Netherlands | CBi - Centre for the Promotion of Imports from developing countries. [online] CBi. Available at: https://www.cbi.eu/market-information/apparel/denim/ [Accessed 10 Mar 2017].


Circle Economy (2017). A key-enabler for ‘textile-to-textile’ recycling is on its way to the market. [online] Circle Economy. Available at: https://www.circle-economy.com/a-key-enabler-for-high-value-textile-to-textile-recycling-is-on-its-way-to-the-market/ [Accessed 23 Apr. 2017].


Graphic Information:


Informative contacts


Bos, Peter, Chairman of Texperium Open Innovation Centre 14-03-2017. Haaksbergen. Tour and company presentation.


Koemans, Marieke. Sales Director at REMO KEY, 12-04-2017, Kingspins Amsterdam, Interview and meeting.

