CIRCLE ECONOMY

CIRCLE CASE STUDY

G-STAR RAW CLOSED LOOP DENIM
BUSINESS CASE & ENVIRONMENTAL IMPACT ANALYSIS

G-STAR RAW

recover
UPCYCLED TEXTILE SYSTEM

WIELAND TEXTILES
First in second hand clothing

0. PROJECT SUMMARY

CIRCLE ECONOMY

Driven by our philosophy ‘Just the Product’, G-Star is focused on the constant reinvention of denim craftsmanship. We push boundaries and continuously investigate new materials, styles and cuts. Innovating for the future also includes taking responsibility for the social and environmental impact of our products.

Giving materials a second life is an ultimate form of sustainable design. We have been pioneering recycled denim since 2008, resulting in new G-Star denim created from our own worn out items that is available since the G-Star Spring/ Summer 2011 collection.

We partnered with Circle Economy with the ambition to investigate further the potential for closed loop business models for G-Star. The Circle Economy assessment was important for G-Star to understand the business case of high value recycling of G-Star returned inventory goods in order to go beyond using recycled denim in capsule collections and to make recycled denim part of the sourcing strategy in the long term.

G-STAR RAW

PROJECT: MAKING THE CASE FOR CLOSED LOOP DENIM

In 2016, G-Star RAW joined Circle Economy to collaborate on creating a hands-on, business driven approach to close the textiles loop. Together with Wieland Textiles and Recover, G-Star and Circle Economy started a pilot project to try and prove the business and environmental case for high value (textile-to-textile) recycling of denim.

The goal of the pilot project was to re-introduce denim goods returned to G-Star and create new denim fabrics that can compete with virgin cotton denim on price, quality and aesthetics at a fraction of the environmental impact. In order to do this, G- Star selected one of their top selling denim fabrics and set out to incorporate recycled content in the making of that fabric. Their intent was to extend the future impact of this project beyond a single capsule collection and make recycled denim part of the sourcing strategy in the long term.

Results from this pilot show that at the present moment, recycled denim fabric has a price premium of 12.5% compared with virgin equivalents. On the technical side, the pilot shows that a maximum of 30% recycled fibres could be used in the recycled yarn in order for it to retain the needed strength for weaving and finishing. Finally, the impact analysis that was performed shows that a recycled denim fabric with only 12% recycled content already has a much lower environmental impact than its virgin equivalent: water consumption can be reduced by 9,8%, energy consumption by 4,2% and CO2 emissions could be cut by 3,8%.

> *"We partnered with Circle Economy with the ambition to investigate further the potential for closed loop business models for G-Star . The Circle Economy assessment was critical for us because we wanted to understand the business case of high value recycling of G-Star returned inventory goods. As a result, we now have a better understanding of the process and can take informed decisions in closing the loop of these goods."* **- Frouke Bruinsma, Director Corporate Responsibility G-Star RAW.**

1. METHODOLOGY, DATA & PROCESS

METHODOLOGY: COMPARING 3 SCENARIOS FOR G-STAR

Circle Economy investigated the business and environmental case for the following scenarios when processing **1 tonne of denim goods** from G-Star: (1) Incineration; (2) Downcycling; and (3) High value recycling. In order to perform the environmental assessment, these scenarios were compared with standard alternative scenarios. Please see page 12-14 for the business case results and page 16-19 for the results of the impact assessment.

Scenario 1 - Incineration

- Denim goods (returned inventory) are collected and transported by waste management companies at G-Star warehouse.
- The textiles are then incinerated by local waste management companies to produce electricity and heat, which is fed back into the energy grid.
- G-Star pays for the transportation and incineration of the waste.
- The impact of this scenario is compared with the alternative of grid electricity production.

Scenario 2 - Downcycling

- Denim goods (returned inventory) are transported from the G-Star warehouse to Wieland Textiles, who sorts and bundles the waste.
- The bales are transported to Frankenhuis, who destroys the textiles into fibres for nonwovens. There is an audit process to confirm safe destruction.
- G-Star pays for the transportation, sorting & bundling, safe destruction, and auditing.
- The impact of this scenario is compared with the production of virgin fibre for similar products.

Scenario 3 - High Value Recycling

- Denim goods (returned inventory) are transported from the G-Star warehouse to Wieland Textiles, who sorts and bundles the waste.
- The bales are transported to Recover, where it is cleaned, recycled, and spun into yarn which contains 30% recycled content. The yarn is transported to the weaving mill, who weaves denim fabrics with ~12% recycled content.
- G-Star pays for transport to Wieland and buys the recycled fabric from the mill.
- The impact of this scenario is compared with the production of equivalent virgin fabric.

METHODOLOGY ENVIRONMENTAL ASSESSMENT

The goal of this research was to identify the key parameters that influence the environmental performance of the recycled textile life cycles and to show the potential benefits of textile-to-textile recycling by comparing recycled yarns and fabrics with the virgin equivalent.

For this goals, a Life Cycle Assessment was performed under the ISO 14040 standards by graduate student Theodoros Spathas. This study assessed the life cycles of the recycled products from the collection of the waste material until the yarn production. The process from yarn to fabric was calculated by Circle Economy based on the Cotton Incorporated study (using a ratio of 60% virgin yarn and 40% recycled yarn in the fabric).

Parameters

- The impact categories assessed for this case study are **climate change, primary energy demand and water consumption (or use).**
- **Functional Unit:** 1 km of uncoloured cotton yarn of 25 Nm (400 dtex).
    - **Alternative 1 (virgin equivalent)**: 1 km of uncoloured yarn of 25 Nm (400 dtex) with composition 100 % virgin cotton.
    - **Alternative 2 (recycled):** 1 km of uncoloured yarn of 25 Nm (400 dtex) with composition 30 % recycled cotton and 70 % virgin cotton.

For the robustness of the results, a sensitivity analysis was performed, using datasets from different types of cotton, to see whether the recycled yarn was more or less sustainable in comparison with the virgin equivalent, depending on the cotton type.

For more information please refer the thesis by Theodoros Spathas titled **“**Thesis: The environmental performance of High Value Recycling for the Textiles Industry.” Chalmers University of Technology, supervised by prof. Greg Peters from Chalmers Technical University (Sweden) and assistant prof. Valentina Prado from Leiden University (the Netherlands).

PROCESS: THE HIGH VALUE RECYCLING APPROACH

During the High Value Recycling pilot project, returned inventory denim goods from G-Star was mechanically recycled into new denim fabric to make new products for G-Star customers. The process was as follows:

1. Returned inventory denim goods are stored at G-Star's facilities in Amsterdam.
2. From there, the denim goods are transported to Wieland Textiles in Zaandam, where the non-recyclable products (eg. accessories, shoes) are removed and the remaining denim goods are bundled together. The materials are bundled in bales of 450 kg as this increases efficiency and safety during transport.
3. Next, the bundled textiles are transported to Recover, an upcycled yarn producer near Alicante, Spain. During the 'cleaning phase', zippers, buttons, rivets and other non recyclable pieces are stripped from the denim garments. Waste materials from this process (±35% of the total volume) are sent to another partner for incineration or downcycling.
4. The cleaned denim fabric is then cut and pulled into cotton fibre. Recycled fibres are then blended together with virgin cotton fibres, carded, and spun into a Ne 9/1 yarn with a make up of 30% recycled denim and 70% virgin cotton. There is a total of 15% waste during the process of recycling and spinning.
5. The recycled denim yarns produced by Recover are then transported to a weaving mill in Turkey. There the yarns are used as weft yarns to create new denim fabric (making up 40% of the new denim fabric's total volume), with a total recycled denim content of 12% (40% * 30% recycled content in yarns = 12% recycled content in fabric).

PROCESS: FROM GARMENT TO NEW DENIM FABRIC

Below we show the mass balance process of recycling denim garments to new denim fabric.
The process starts with G-Star returned inventory denim goods, which is turned into fibre, then yarn and eventually new denim fabric. The process has been normalised for 1 kg of denim garments. From this process flow it becomes clear that 1 kg of denim garments is recycled into 4,65 kg or 7,05 meters (4,65/0,66=7) of denim fabric. Main assumptions:

- There is 35% waste in cleaning step, 5% waste in recycling step and 10% waste in the spinning step.
- Yarns with 30% recycled fibres are used in the weft which is 40% of the total weight of the fabric.
- The denim weighs 0,66 kg per metre (fabric is 0,407 kg per M^2 and 1,62 meters wide).

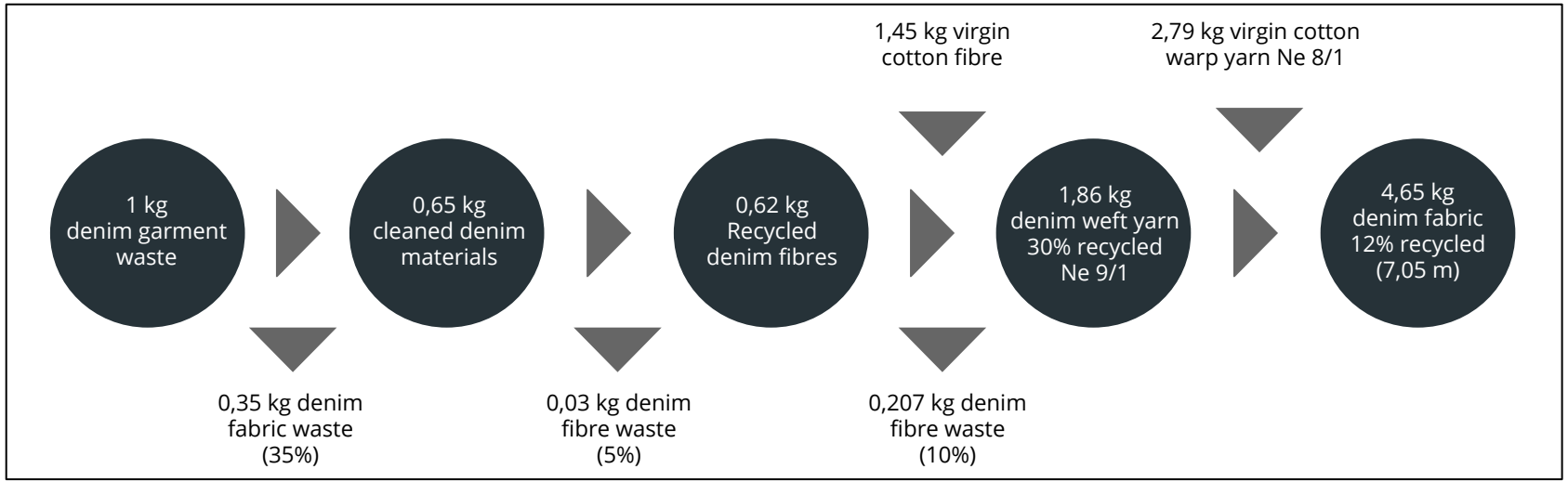
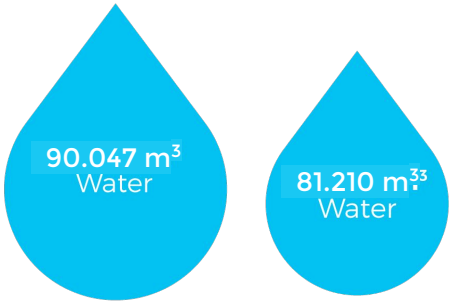


Figure 1: process flow showing mass balance of recycling 1 kg of denim garments.

4. RESULTS IMPACT ASSESSMENT

ENVIRONMENTAL IMPACTS of recycled vs virgin denim

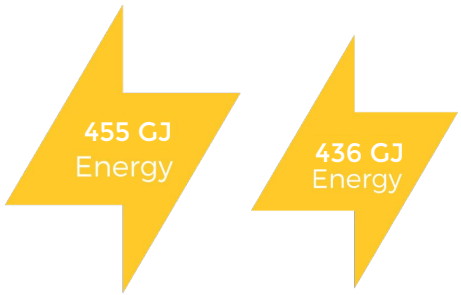
Recycled denim fabric has a significantly lower environmental footprint than virgin denim fabric. High value recycling reduces water usage by 9,8%, energy consumption by 4,2%, and CO2 emissions by 3,8%. Results below are based on mechanically recycling 1 tonne of denim goods to produce 7.050 m (4.65 tonnes) of denim fabric with a make up of 12% recycled content. Impact savings in water, energy and CO2 of the recycled fabric, can be mainly attributed to the avoidance of cotton cultivation. Results show moderate impact savings for energy and CO2. This is due to the fact that unlike water, energy and CO2 contribute less to the footprint of cotton cultivation and because the CO2 emitted and energy required for pre-processing textiles for recycling (including transport and industrial processes) are taken into account.



Virgin Recycled

Water consumption Reduced by 9,8%

Avoidance of virgin cotton. Recycled cotton uses minimal amounts of water, which leads to the overall decrease of water usage.



Virgin Recycled

Energy consumption reduced by 4,2%

Spinning and weaving are the highest contributors to primary energy consumption and they do not change in recycling.

Virgin Recycled

CO2 emissions reduced by 3,8%

Recycled cotton **avoids greenhouse gas emissions from cultivation,** such as fertiliser and pesticide production and use.

WATER NET SAVINGS per tonne of recycled G-Star denim goods

CIRCLE ECONOMY

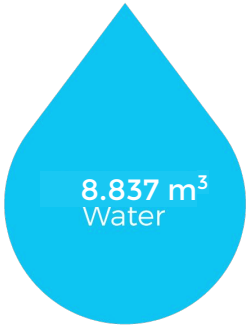
Cultivation of cotton is a very water intensive processes that is avoided in the high value recycling scenario. Reduction in water consumption is also evident in downcycling, while incineration has the lowest savings. To calculate the net water savings, we have not included the impact savings of recycled yarns related to dyeing of virgin equivalent yarns. This is because for standard denim fabrics, the virgin equivalent weft yarns are not dyed. Therefore we can not include this effect in calculating the net water savings.

Scenario 1
Incineration
Vs.
Grid Production

Net water savings of 10 m3 (10.000 L) per tonne of denim goods incineration to create electricity and heat.
Equal to ±210 showers.

Scenario 2
Downcycling
Vs.
Virgin Fibre

Net water savings of 2.698 m3 (2,7 million L) per tonne of denim goods downcycled to produce fibre.
Equal to ± 57.000 showers.



Scenario 3
High Value Recycling
Vs.
Virgin Fabric

Net water savings of 8.837 m3 (8,8 million L) with high value recycling, due to avoidance of cotton cultivation.
Equal to ± 186.000 showers.

ENERGY NET SAVINGS
per tonne of recycled G-Star denim goods

CIRCLE ECONOMY

Spinning and weaving are the highest contributors to energy consumption and these impacts are not avoided with recycled yarns. However, high value recycling saves energy, with the avoidance of cotton cultivation. Savings are less for downcycling and minimal for incineration.

Scenario 1
Incineration
Vs.
Grid Production

Net energy saving are 0 GJ per tonne of denim goods incinerated to create electricity and heat.

Scenario 2
Downcycling
Vs.
Virgin Fibre

Net energy savings are 10 GJ per tonne of denim goods downcycled to produce fibre.
Equal to half the annual energy of 1 household in the UK.

Scenario 3
High Value Recycling
Vs.
Virgin Fabric

Net energy savings are 19 GJ per tonne of denim goods processed into 1 tonne of fabric.
Equal to the annual energy for 1,9 households in the UK.

CO2 EMISSIONS NET SAVINGS
per tonne of recycled G-Star denim goods

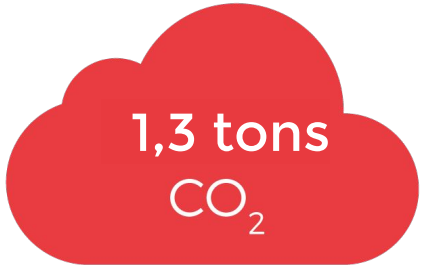
By avoiding cotton cultivation, high value recycling leads to the highest reduction in CO2 emissions. In scenario 1, the impact is negative, since it costs more CO2 emissions* to produce energy from incineration** of denim goods, than with standard grid production.

Scenario 1
Incineration
Vs.
Grid Production

1 tonne of net CO2 is emitted (negative impact) per tonne of denim goods incinerated
Equal to ± two long distance flights per person.

Scenario 2
Downcycling
Vs.
Virgin Fibre

There are **minimal savings** in carbon emissions per tonne of denim goods downcycled to produce fibre.



Scenario 3
High Value Recycling
Vs.
Virgin Fabric

High Value Recycling has the **highest net emission savings** of all scenarios.
Equal **to ± two long distances flights** per person.

*incl. Biogenic CO2
**CO2 equivalents

5. CONCLUSIONS & FINAL CONSIDERATIONS

CONCLUSIONS: TECHNICAL CHALLENGES

For a few years, mills have been producing yarns containing recycled denim obtained from pre- and post consumer garments. Denim fabrics with up to 20% recycled post consumer denim, are already available on the market. From this, we can conclude that denim to denim recycling IS possible. However, it is also clear that recycled denim does not have the same performance (strength) and consistency as non recycled denim.

Pilot project conclusions:

- Not all denim styles can be created with recycled yarns. Due to the inferior strength of recycled denim fabrics in which up to 30% of the fabric is made from recycled yarns (RKM 10.5 vs the needed 12.5), certain resin finishings cannot be applied.
- Recycled denim yarns are best used in the weft (not warp) to (1) keep the original look and feel which is determined by the warp yarn and (2) because the weaving process puts less ‘stress’ on the weft yarn.
- Possibilities and limitations on a fabric level are determined by the characteristics of the recycled yarns and therefore different yarns will generate different outcomes.

For G-Star, superior strength is needed to create the denim look they desire. Further trials will be done to improve the strength and performance of the yarn (reducing the use of recycled yarn to 20% with an RKM of 12.1) and the look of the fabric.

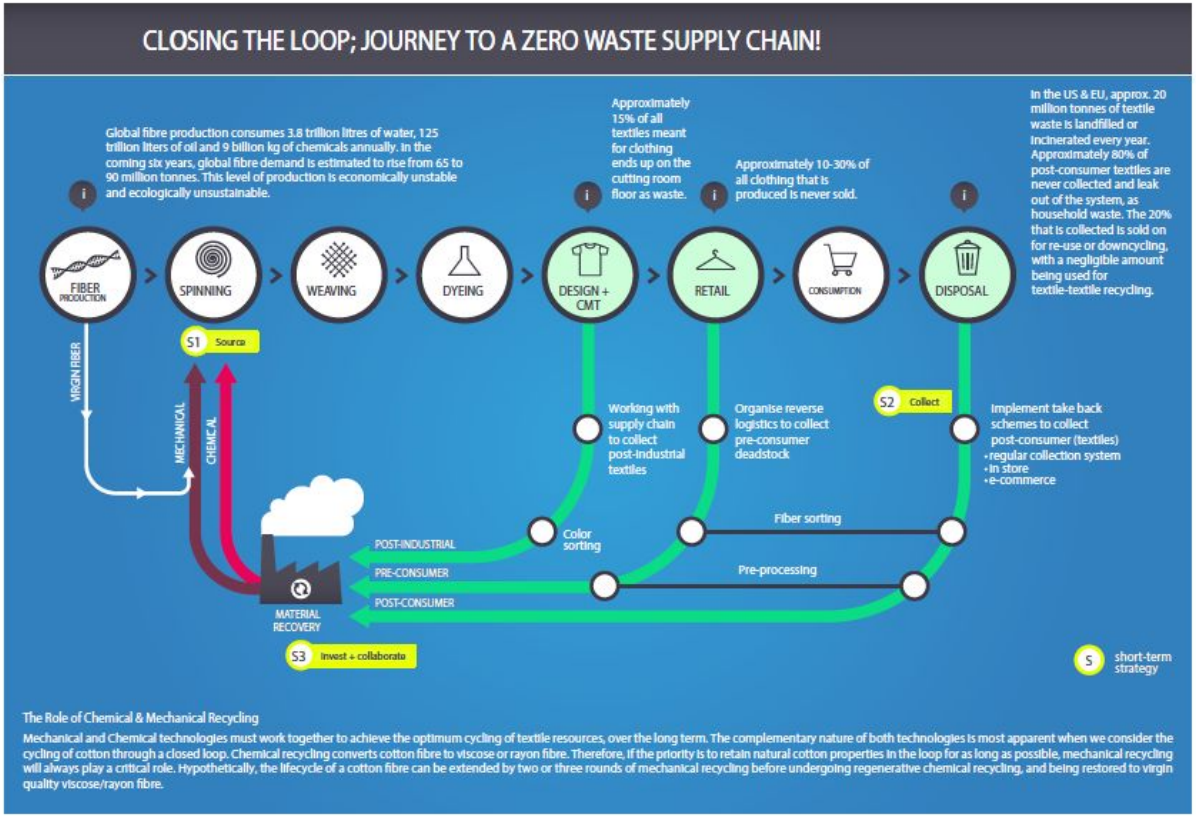
CONCLUSIONS: THE BUSINESS CASE

Results from this pilot show that at the present moment and given the specified conditions, recycled denim fabric has a price premium of 12,5% and therefore cannot be considered competitive with the virgin equivalent. However, costs of alternative scenarios like incineration or downcycling can be avoided when applying the high value recycling scenario, effectively reducing this price disparity slightly. Other aspects also can contribute to making recycled denim more competitive compared to virgin: (1) Growth of market pull for recycled resources and upscaling of mechanical recycling processes and (2) forecasted future price rises for virgin cotton (2025). Alternatively, recycling of denim goods into non-denim, knitted fabrics for products like beanies, scarves, and sweaters can provide a more commercially attractive option on the short term. This due the fact that % recycled in these fabrics can be much higher than in denim fabrics, making it more cost effective.

APPENDIX I: ENVIRONMENTAL IMPACTS OF THE TEXTILES INDUSTRY & POTENTIAL FOR MECHANICAL RECYCLING

IMPACTS OF TEXTILE WASTE

CIRCLE ECONOMY



A roadmap for creating a zero waste supply chain: closing the loop for post industrial, pre consumer and post consumer textiles.

IMPACT OF DENIM WASTE

While denim has a long life span due to its timelessness and material durability, a large volume is still destined for landfills or incinerators. While the latter option does produce useful energy, valuable materials which could have been reused to make new higher value end products are destroyed.

Additionally, some denim is being recycled into lower value products such as felt and insulation in a recovery process known as downcycling. However, this process diminishes the fibre quality and prevents further circulation of a fibre that has the potential to produce high value products.

The inherent value of this post-industrial, pre-consumer and post-consumer textile waste is not captured in the economy's current linear model. Most of these textiles could be regenerated through high-value recycling routes and the use of mechanical or chemical recycling processes to create new fibres, fabrics and products. Ultimately, high-value recycling would allow the industry to reduce downstream waste and displace the need for virgin fibre upstream in the long-term.

HIGH POTENTIAL FOR HIGH VALUE RECYCLING

High value or textile-to-textile recycling enables leftover textile fabrics or garments that are no longer in use to be redirected back into the textiles loop as recycled raw materials. Currently, textile 'waste' streams throughout the supply chain remain a largely untapped resource due to the lack of established technologies, processes and business models to redirect these fibres back into the loop. This is however quickly changing due to growing interest of Industry in circular economy based business models and through technological advancements that can enable a circular textiles industry.

- During the production stage, up to 15% of textile 'waste' is generated, creating a post industrial textile 'waste' stream of ±13.5 million tonnes* of textiles annually.[8]
- In the retail stage, it is often reported that up to 33% of garments are never sold, which can add up to 20 million tonnes* of textiles annually. In many cases this pre consumer textile 'waste' stream is destroyed to avoid flooding the market.[9]
- In the US and EU, approximately 85%[10] and 75%[11] of used textiles end up in landfill and incineration respectively. This adds up to a post consumer textile 'waste' stream of ±14 million tonnes per year. If these textiles would be collected, ±55% could be reworn; ±20% could be downcycled and used as materials in other industries, and ±20% would be suitable for textile-to-textile recycling.[12]

Leveraging these untapped 'waste' streams to create new textiles on a large scale would drastically cut the need for virgin textile resources and significantly reduce the negative impacts associated with virgin cotton fibre production and textile waste.

Mechanical recycling methods are already playing a crucial role in paving the road for 'textile to textile' solutions that proximate virgin quality and are ready for further scaling. Furthermore, game changing chemical technologies are on the horizon and expected to provide the scalability that is needed to generate a global closed loop for the textiles industry.

*Rough estimations based on approximate percentages known in the market and a global textile fibre production of 90 million tonnes per year.

G-STAR RAW

Since their creation in 1989, G-Star's philosophy has always been, 'Just the Product.' G-Star is focused on the constant reinvention of denim craftsmanship. They push boundaries and continuously investigate new materials, styles and cuts.

CIRCLE ECONOMY

A social enterprise, organised as a cooperative, Circle Economy accelerates the transition to circularity through on the ground, action focused, development of practical and scalable solutions and international campaigns, communications, and engagement, focused on spreading the circular message.

WIELAND TEXTILES
First in second hand clothing

Wieland Textiles is a sorting company based in the Netherlands, with 45 employees , who process 7 to 8 Kt of used textiles annually. Over 200 tonnes of clothes a week a sorted on the basis of type, size and quality.

recover®
UPCYCLED TEXTILE SYSTEM

Since 1947 the Ferre family has been producing upcycled cotton yarns in Banyeres de Mariola, Spain. The Recover Upcycled Textile System regenerates cotton fiber from old clothing and cutting scraps. Recover cotton is produced using none of the water and toxic chemicals required for conventional cotton fiber.

Source List

1. Global Fibre Overview, 2014
2. Sustainable Textiles for Apparel: Fact, Fiction and Future Prospects
3. Roadmap to Sustainable Textiles and Clothing
4. The Impact of Cotton on Freshwater Resources and Ecosystems
5. The Impact of a Cotton T-Shirt
6. Council for Textile Recycling
7. Textiles Environment Design: Recycling and Upcycling
8. A Stitch in Time: Lean Retailing and the Transformation of Manufacturing -- Lessons from the Textile and Apparel Industries
9. Fashion Data: On the Failing Fashion System and Alternative Solutions
10. Council for textile recycling: the facts about textile waste
11. Ecouterre: Europe Only Recycles 25 Percent of Textile Waste, Says New Report
12. TED: recycling & upcycling and field research at Wieland textiles
13. The United Nations World Water Development Report 2015 : Water for a sustainable world.