Reformation

RefScale methodology - Apparel

The Reformation sustainability team created a life-cycle assessment tool to calculate the CO2 and water footprints of Reformation products, as well as comparable products. The tool uses primary data whenever available; otherwise it references secondary data and existing life-cycle assessments for select fabrics or processes. Finally, a third-party sustainability consulting team reviews this methodology and data sources (annually as needed) to verify the validity of Reformation's calculations[1].

Goal and scope

The goal of this RefScale is to compare the environmental impact of manufacturing clothes at Reformation vs comparable products. The scope is a cradle-to-grave assessment including raw material inputs into fabric manufacturing, fabric dying, product manufacturing, packaging, transportation, customer care, and end-of-life disposal. A generic system diagram for the tool is shown in **Figure 1.**

The tool is built for calculating the environmental impact of a garment made with one fabric (i.e. self) or two fabrics (i.e. self & lining). A garment made just with one fabric will follow all the processes outlined in **Figure 1** and detailed in the Inventory Analysis. For garments that have a self fabric and a lining fabric, lining fabric emissions are calculated separately, following the same process, and added to the total emissions of the garment.

Deadstock fabrics are defined as verified old, leftover, and over-ordered fabric from other designers and fabric warehouses. For deadstock fabrics we do not assign a fabric impact since these come from secondary markets. However, we do calculate the rest of the life cycle impacts defined in **Figure 1**.
The system boundary for the RefScale tool for shoes only focuses on four major components of shoe production. These four major components are the upper, sock, and the bottom (both outsole & heel). For shoe bottoms, ABS & rubber weights were assumed to be the rest of the total shoe weight. E.g. **[Total weight-(upper weight +sock weight)] =Bottom weight**. If the shoes had both ABS & rubber the weight was split in half.

Functional unit

The functional unit in this tool is defined as one garment of clothing. It can be a dress, a jumper, a blouse, etc. The emission factors that are used in calculating the processes defined in **Figure 1** (i.e. fabric dying, transportation, etc.) are normalized to one pound and are used to calculate the CO2 and water for one garment of clothing made at Reformation and one garment of comparable conventional clothing.

A notable exclusion from the tool is trims such as zippers, buttons, and fasteners. Previous studies have found trims are not relevant relative to other life cycle stages. Another notable exclusion is e-commerce impacts (per product). Reformation researched resource use of data centers and customers' computer usage and found that the impacts were negligible. However, the footprint of Reformation's online shopping platform (i.e. CO2 eq emissions) of servers and customer screen power consumption is calculated and offset separately.

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[1]Last reviewed: April 2022 by Anthesis

Inventory analysis

Fabric Manufacturing

1. Emission Factors

The main source of our fabric impacts comes from the Higg Materials Sustainability Index (Higg MSI) developed by the Sustainable Apparel Coalition (SAC). The Higg MSI assesses impacts of materials from cradle-to-gate for a finished material (i.e. to the point at which materials are ready to be assembled into a product). The Higg MSI scores or percent calculations provided herein account for a single production stage within the Higg MSI scope (e.g. fiber or raw material). They do not provide a holistic view of the impacts involved with material production.

If a specific fabric is not listed in the MSI we've identified LCAs that have similar boundaries and geographic focus for secondary sources. We've done our best to compare "apples-to-apples" but in some cases, this is very difficult with existing data. We try to focus on cradle-to-gate, and will select the most thorough and conservative estimates when competing studies and data are available.

2. Comparable Conventional Clothing

Our conventional clothing comparisons are in line with Textile Exchange's conventional assumptions in their Corporate Fiber & Materials Benchmark (CFMB), Program Sustainability Weight. The Program Sustainability Weight refers to the weight allocated to each fiber to help determine a company's relative uptake performance score based on the share of preferred material uptake relative to conventional. It's important to note that not all fibers are listed in the CFMB so some comparisons are made based on what fabrics and processes that Reformation assumes are most common for products sold in the US. All conventional comparisons are listed in **Figure 2**.

3. Blended Fabrics

For blended fabrics, fabric impacts are calculated by fabric composition. E.g. a fabric that is 50% organic cotton and 50% linen, the fabric impacts would be calculated assuming 50% of the impact is attributed from organic cotton and 50% is from linen.

For conventional blended fabrics, the impacts are calculated the same way and mapped to the applicable conventional fabric defined in **Figure 2**. E.g. for the same fabric listed above the impacts would be calculated assuming 50% of the impact is attributed from conventional cotton and 50% is from linen.

4. Deadstock Fabrics

Deadstock fabrics are defined as verified old, leftover, and over-ordered fabric from other designers and fabric warehouses. For deadstock fabrics, we do not assign a fabric impact since these come from secondary markets.

Fabric Dyeing

Dyeing calculations assume reactive dyeing processes for Reformation and Conventional garments. Solid fabrics use an emission factor for reactive dyeing done in India & China. Printed fabrics use a conventional print emission factor. Reformation uses third-party certifications (i.e. GOTS, GRS, Bluesign, Oeko-Tex) for low-impact and safe dye practices when available. The tool is currently unable to identify LCA reporting for dyeing emission factors when these certifications are being used so the low-impact dyeing is not taken into consideration in this version of the tool.

Material Transit

Reformation defines material as finished material (i.e. fabric, leather) that is ready for product manufacturing. Material transportation is calculated in miles from the material vendor's location to Los Angeles. The specific emission factor that is used to calculate the impact is dependent on the transportation mode (i.e. truck, ship, air). The material transit for conventional clothing is assumed to be air transport from China to LA.

Product Manufacturing

Manufacturing impacts are calculated on a per unit basis based on the sew vendor location. The facilities are broken down into three categories: In House, Out House, and Overseas. In House is defined as garments that are produced in the Reformation factory in Vernon, CA. Out House is defined as garments that are produced in Los Angeles at one of Reformation's partner factories. Overseas is defined as garments that are produced overseas at one of Reformation's partner factories.

Depending on which category the garment is sewn in, a different emission factor is applied for product manufacturing CO2 & water. The emission factors used for CO2 and water were gathered by collecting primary data on their energy & water bills from various vendors at different manufacturing locations. Manufacturing impacts were calculated by dividing the monthly average (kWh & HCF) by the average monthly volume of units.

A notable assumption for conventional clothing is that it is manufactured in China in a factory without carbon offsets.

Commercial Garment Wash

The tool assumes that for both Reformation & conventional clothing, only denim is commercially washed in a commercial-top load machine with a container volume of 2.8 cu.ft. and a maximum test-load weight of 11.7 lb/cycle. Reformation primarily makes denim in Los Angeles & Turkey so the emission factor associated with the commercial garment wash is dependent on the sewing vendor location.

Current limitations

There are some slight variations in system boundary and geographic focus for secondary sources. We've done our best to compare "apples-to-apples" but in some cases, this is very difficult with existing data. We do our best to focus on cradle-to-gate, and will select the most thorough and conservative estimates when competing studies and data are available.

Conventional denim assumes that the commercial washing process occurs in China.

Packaging

Reformation packaging includes a 100% recycled LDPE polybag in a 100% recycled content mailer. Conventional packaging assumes 100% conventional plastic polybag in a 100% conventional plastic mailer. Packaging impact includes manufacturing as well as the end-of-life impact for all materials used for both clothes and shoes.

Shipment

Reformation shipping is assumed to be small-package, ground shipping with carbon offsets. The tool notes this by zeroing out the impacts for shipping for Reformation garments because the impacts are calculated by the shipping providers and offset through a carbon neutral shipping program. Conventional clothing shipping is assumed to be small-package, ground shipping without carbon offsets.

Garment Care

The tool assumes that the Reformation customer follows recommended garment care instructions. Reformation clothes that have care instructions that are "green dry clean" assume that the customer follows recommended garment care instructions instead of traditional professional cleaning. For Reformation clothes that have care instructions "machine wash", garment care calculations are based on using cold water and higher-efficiency front-loading machines. For conventional clothes, machine washing for home garment care calculations are based on using warm water. Garment care emission factors for machine washing include both wash & dry. The tool also assumes that the average life of a garment is 52 washes for both Reformation & conventional clothing.

End-of-life

The tool assumes Reformation customers recycle at a slightly higher rate than the US average (16% vs.14%) according to the EPA. This can be attributed in part to the different recycling and resale options we offer on our website and their increased awareness of clothing waste.

Sources

Sources used to calculate the environmental footprint include a mix of primary and secondary data, including other life cycle assessments, material databases, and scientific literature reviews. Primary data is used when available and is triangulated with reputable, industry-specific data. A summary of key data sources by life cycle stage is listed on the next page:

Life Cycle Stage	Dats Sources
Fabric Manufacturing	•Carbon & Water intensities from Higg Materials Sustainability Index, supplier LCAs, and LCA databases. •2019 CFMB Scoring Methodology Textile Exchange © 2019 https://textileexchange.org/wp-content/uploads/2020/01/2019_CFMB_Scoring_Methodology.pdf
Fabric dyeing	•"SimaPro (Ecoinvent Database, Method Ecoindicator 95)"
Material Transit	•WTW emission factors from the 2019 GLEC Framework
Product Manufacturing	•Primary energy & water consumption data from the Reformation factory and partner factories.
Commercial Garment Wash	•California Source: (2016, egrid) •Turkey Source: Ecoinvent •China Source: https://www.carbonfootprint.com/docs/2019_06_emissions_factors_sources_for_2019_electricity.pdf •Energy Efficiency and Renewable Energy Office, 2006
Packaging	•Earthsmart •Al-Ma'adeed, M., Ozerkan, G., Kahraman, R., Rajendran, S., & Hodzic, A. (2011). Life Cycle Assessment of Particulate Recycled Low Density Polyethylene and Recycled Polypropylene Reinforced with Talc and Fiberglass. Key Engineering Materials, 471–472, 999–1004. https://doi.org/10.4028/www.scientific.net/kem.471-472.999
Shipment	•Primary Data from our shipping providers
Garment Care	•Apparel Industry Life Cycle Carbon Mapping, Business for Social Responsibility, June 2009 •Barthel, Claus., Gotz, Thomas., What users can save with energy and water efficient washing machines, BigEE March 2013 •Do all laundry by hand, Three Actions Project, As of October 2010 •Residential Clothes Washer Introduction, Alliance for Water Efficiency, As of October 2016
End-of-Life	•EPA •Earthsmart

Figure 1 RefScale system boundary.

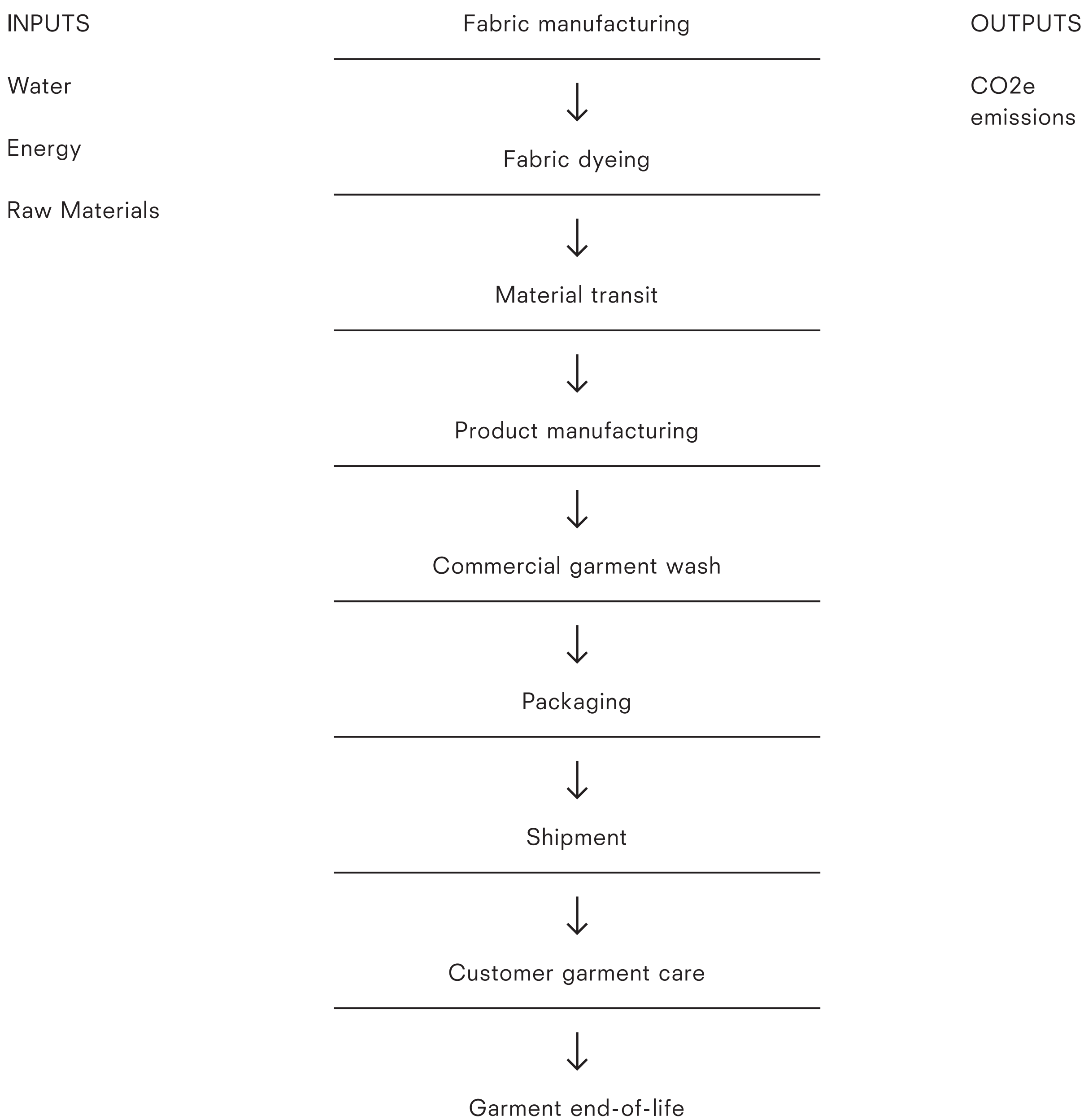

Figure 2 Comparable conventional clothing assumptions.

When it comes to innovative fibers Reformation determines comparable conventional fibers by looking at their replacement potential based on quality rather than similar production processes. For example, at Ref we are starting to replace silk by Naia™ Renew.

Reformation Fabric	Conventional Fabric
Acetate	Acetate
Acrylic	Acrylic
Alpaca	Alpaca
Baby Alpaca	Alpaca
Birla Staple Viscose	Generic Viscose
Cashmere	Cashmere
Cotton	Cotton
EcoLycra	Nylon
ECONYL® Regenerated Nylon	Nylon
ECOVERO™	Generic Viscose
ECOVERO™ Viscose	Generic Viscose
Elastane	Spandex
Jute	Jute
Leather	Leather
Lenzing Asia Viscose	Generic Viscose
Lenzing Modal	Generic Viscose
Linen	Linen
Lyocell	Generic Viscose
Mechanically Recycled Polyester	Polyester
Micro Tencel	Generic Viscose
Nylon	Nylon
Organically grown cotton	Cotton
Polyester	Polyester
Rayon	Generic Viscose
Recycled Cashmere	Cashmere
Recycled Cotton	Cotton
Recycled Nylon	Nylon
Recycled Polyester	Polyester
Recycled Wool	Wool
REFIBRA™ Lyocell	Generic Viscose
Regenerative Cotton	Cotton
REPREVE® Polyester	Polyester
Responsible Wool	Wool
Silk	Silk
Spandex	Spandex
Tencel	Generic Viscose
TENCEL™ Lyocell	Generic Viscose
Viscose	Generic Viscose
Wool	Wool
Yak	Wool
Modal	Modal
NAIA™ Acetate	Viscose
NAIA™ Renew Acetate	Silk

RefScale methodology - Shoes

We developed a version of the above tool customized to shoes.

Shoes are assessed by several components:

- **Upper**
- **Lining**
- **Sock, which includes the midsole and insole**
- **Heel/Wedge**
- **Foam/Insole**
- **Bottom wrap, which refers to materials wrapped around the heel**
- **Outsole**
- **Toplift**

Other materials such as trims, upper stitch, were excluded from the analysis due to lack of materiality and/or information.

Shoes were also divided up into categories, in order to account for average weights per component per category (e.g. the Upper of a loafer), as well as average carbon and water values for manufacturing and some transportation calculations. The categories were loafers, ballet flats, flat mule, flat sandals, heeled sandals, wedge sandals, and platform sandals.

1. Materials and Blends

Blends were calculated by allocating the carbon and water impacts by percent weight of the materials. Additives such as expanders, fillers, etc were not analyzed due to lack of information on these materials. Blends that contained these additives were therefore adjusted so that the remaining materials were proportionately increased to equal 100%.

Most materials were found in Higg, which included Tier 5 (raw material) to Tier 2 (material production) transportation default information. For materials derived from Ecoinvent, market values were used to estimate global distances. For materials derived from literature, a proxy material distance was used. Reformation leather was modified within Higg MSI to be sourced from Brazil.

Some modifications were made for blends and materials not found in the Higg MSI:

•Sustainable EVA Blend
-Information on the Green EVA portion was provided by an externally reviewed LCA developed on behalf of the manufacturer Braskem. Carbon intensity was based on pellets; therefore mixing and foaming default values were added in from Higg MSI.
- Green EVA portion Tier 5 to Tier 2 distance was assumed to be same as the default Fossil Fuel EVA (from Higg MSI).
-Fossil Fuel based EVA portion was based on Higg MSI values.
-Molding/prep was not included, as this was assumed to be captured in T1 manufacturing.
-Water values for both the green EVA and fossil fuel EVA were assumed to be the same, due to the

Braskem LCA lacking AWARE water scarcity values. Water values did not include molding/prep, as this step was assumed to be performed within the T1 manufacturing phase.

•Bio-veg blend
-The bio-polyol carbon intensity was derived from literature (Fridrihsone, Anda & Romagnoli, F. & Kirsanovs, Vladimirs & Cabulis, Ugis. (2020). Life Cycle Assessment of vegetable oil based polyols for polyurethane production. Journal of Cleaner Production. 266. 121403. 10.1016/j.jclepro.2020.121403). The paper reported GHG savings of bio-polyol production over petrochemical feedstock of 70%; therefore, these savings were applied to the leather coating values of synthetic leather in the Higg MSI.
-Values were calculated first based on materials (bio-polyol, PU, and recycled polyester). The values of subsequent synthetic leather processing steps were added in (needle punching, wet and dry process, hydrolysis).
-No water scarcity information was available; therefore, water scarcity was assumed to be equivalent to synthetic leather (via Higg MSI).

•Post-consumer ABS, as part of a blend
-The carbon and water values were derived from publicly available database information. Because literature values were based on pellet form, the mixing/prep, and molding/curing values were added from Higg MSI ABS. In addition, since the literature values did not take into account transportation, Tier 5 to Tier 2 transportation was added to be equivalent to default ABS transportation (via Higg MSI).

•Sustainable Recycled SBR Blend with Low % of Natural Rubber
-The carbon and water values of the recycled SBR portion of the blend was reduced 70% for CO2e and increased 200% for water, based on virgin SBR values. These percent reductions were derived from the difference between virgin and recycled butyl rubber raw material values in the Higg MSI, because the two rubbers likely undergo similar recycling processes to reach the raw material/pellet phase.

•Recurro blend
-The regenerated leather portion of Recurro was assumed to have zero water and carbon values because it is deadstock.
-The acrylic binder values were derived from ecoinvent.

•60% PU, 40% Recycled PU, and Recycled TPU blend
-The carbon and water values of the recycled PU and TPU raw material portion of the blend was reduced 80% for CO2e and 82% for water, based on virgin PU and TPU values, respectively. These percent reductions were derived from the difference between virgin and recycled polypropylene raw material values in the Higg MSI, because the two plastics likely undergo similar recycling processes as polypropylene to reach the raw material/pellet phase.

•Recycled PVC blend
-The carbon and water values of the recycled PU raw material portion of the blend was reduced 80% for CO2e and 82% for water, based on virgin PU values. These percent reductions were derived from the difference between virgin and recycled polypropylene raw material values in Higg MSI, because the two plastics likely undergo similar recycling processes to reach the raw material/pellet phase.

2. Conventional Material Comparisons

Reformation shoes were compared to conventional shoes based on material choice, packaging, and EOL options. Other components of the lifecycle were assumed to be the same, including the distance from the material production facility to the product assembly facility, and the manufacturing energy and water use at the finished product assembly facility.

Conventional Materials

Conventional materials were chosen using defaults in the Higg MSI, including global averages. Below is the initial list of comparisons for conventional materials that differed from Reformation materials.

Reformation Material	**Conventional Comparison**
Chromed and chrome free leather	Conventional (Cow) Leather
Bio Veg	Synthetic Leather
Recycled Blend ABS	ABS
Recycled PVC Blend	ABS
Recycled TPU Blend	TPU Rubber
Sustainable EVA Blend, Sustainable EVA Blend (Midsole), Sustainable EVA Blend- Foam Sock	EVA (excluding molding)
Sustainable Natural Rubber and SBR Blend	Conventional rubber
Sustainable Recycled SBR Blend with Low % of Natural Rubber	Conventional rubber
Recurro	Conventional (Cow) Leather
60% PU 40% Recycled PU	ABS

3. Manufacturing

Manufacturing impacts were based on electricity use at each Tier 1 facility, the annual volume of Ref production as a percent of the total operation. Water use associated with manufacturing was assumed to be zero. Ecoinvent values for medium voltage electricity in Brazil were used. Conventional manufacturing was assumed to be the same.

4. Packaging

Reformation packaging was compared to a conventional women's shoebox in Higg MSI(material only), which was composed of virgin cardboard. It was assumed that packaging was completed at Tier 1 facilities.

Reformation packaging was based on recycled and primary materials found in Higg MSI. Impacts associated with manufacturing the boxes was assumed to be an additional 33%, based on energy used in the Higg MSI conventional box production. No manufacturing information was available for assembling the boxless packaging; therefore, this was not included. The linen used in the boxless packaging was assumed to be conventional, virgin linen.

5. Transportation

Transportation from Tier 2 to Tier 1
Distances from Tier 2 to Tier 1 facilities were based on Reformation values. Conventional distances were assumed to be the same.

Transportation from Tier 1 to Distribution Center (DC)

Carbon and water intensity values were derived from Ecoinvent (per km-kg). The distance from Tier 1 to DC was assumed to be by air from Brazil to Los Angeles. Because shoes were packaged at Tier 1 facilities, each pair of shoes shared one trip. In addition, the boxes and the bagless solutions have different weights, also affecting the final carbon and water values. Conventional distances were assumed to be the same.

Transportation from Distribution Center (DC) to Customer

CO2 values were derived from RefScale for garments, which assumed zero impacts for shipping from Ref, and 1.36 lbs on average for each package. Water impacts were not available and therefore were excluded.

6. Use

Use was not considered for this model, as there is insufficient information on how often the average customer resoles or reheels their shoes, and could be as low as 10%.

7. End of Life

Reformation shoes can be accepted by Looptworks, which can reuse the shoes as ingredients for other materials. These include replacement virgin aggregate and light fill material in civil engineering applications (e.g. roads, rail baseballs, drainage layers, leachate collection), embankments, and wall repairs. Other uses include wheel stops in parking lots, equestrian and sports courts, and slip resistant mats.

EOL impacts for Reformation shoes were assumed to be zero, since they are reused in other systems. Conventional shoes are assumed to be landfilled, with ecoinvent values for conventional landfills applied.