Otrium × Vayu

Methodology

Quantifying Otrium's Avoided Impact in 2023

Contents

Introduction

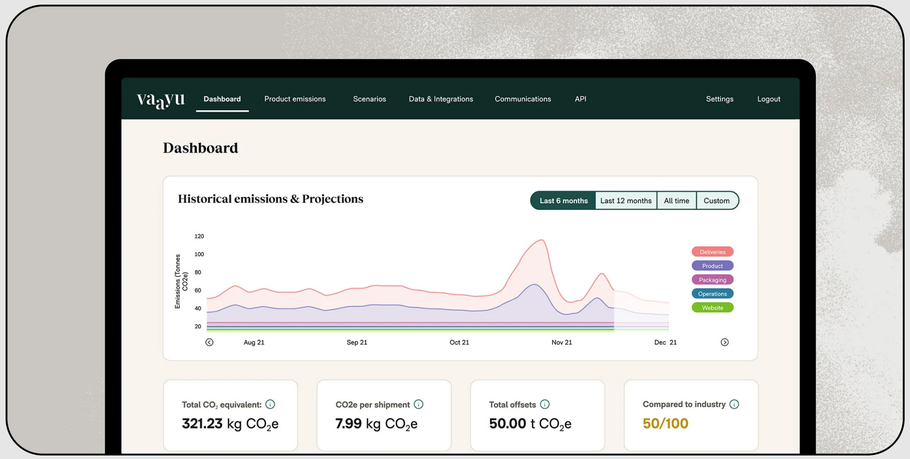
Otrium

Otrium is a purpose-driven platform that envisions a world where all clothing that is produced is worn. Founded in 2017 in Amsterdam by Milan Daniels and Max Klijnstra, Otrium seamlessly connects a global community of 5 million members to excess stock from leading brands through its technology-led approach. Otrium partners with 300+ beloved brands, empowering consumers to choose conscious options beyond trends and seasons while giving fashion brands a lasting presence outside traditional models. The team envisions a future where every garment finds its rightful place and is steadfast in its goal to ensure no new clothing ends up in landfills. Otrium is on a mission to change the industry while putting the best fashion deals online.

Vaayu

Vaayu is the world's first automated software empowering brands and businesses within the retail industry to track and cut their carbon and environmental impact in real-time. By leveraging proprietary AI and machine learning technology, Vaayu calculates impacts like emissions, water and waste across product, packaging and logistics using certified[1] life cycle assessment (LCA)[2] methodology to provide granular insights and inform data-driven decision-making.

Named one of TIME's Best Inventions[3] and with more than 100 brand partners, Vaayu has pioneered research into the climate impact potential of circular business models and calculated product footprints at scale for partners including Klarna, New Balance and Redcare Pharmacy.



1. Vaayu's methodology is certified by TÜV Rheinland.
2. LCA is a systematic method for evaluating the environmental impacts of a product or service throughout its entire life cycle, from raw material extraction to disposal.
3. Vaayu is one of TIME's Best Inventions 2022 in the Sustainability category.

Introduction

Retail’s changing regulatory environment

The European Union’s Ecodesign for Sustainable Products Regulation (ESPR), a key part of the EU’s Circular Economy Action Plan and the European Green Deal, marks a transformative step in sustainable product regulation.

ESPR

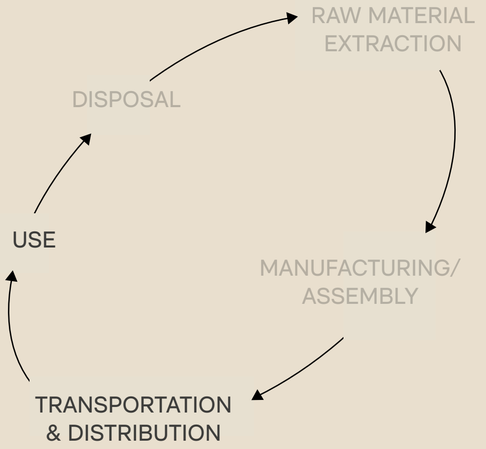
Adopted in May 2024, ESPR[4] extends beyond traditional energy-related products to include a wide array of goods, such as textiles. This legislation establishes a framework that will result in binding performance and disclosure requirements and further introduces a pioneering ban on the destruction of unsold textiles, challenging the industry, including brands, to rethink waste and life cycle management.

In this evolving regulatory landscape, brands face the dual obstacles of compliance and sustainability, particularly in handling unsold stock.

4. The ESPR was adopted by the European Council in May 2024. After being signed by the President of the European Parliament and the President of the Council, the regulation will be published in the Official Journal of the European Union and will enter into force on the 20th day following that of its publication. It will apply from 24 months after the entry into force.

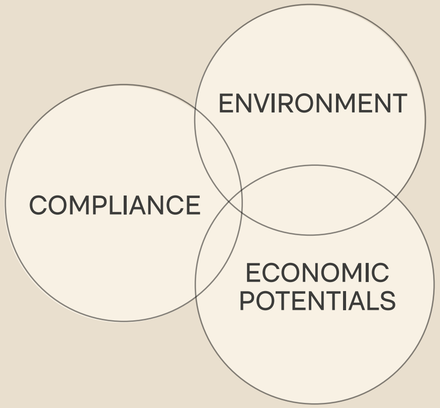
That's where Otrium comes in — a purpose-driven platform with an innovative off-price business model that offers a compelling and lucrative clothing sales solution by repurposing unsold stock.

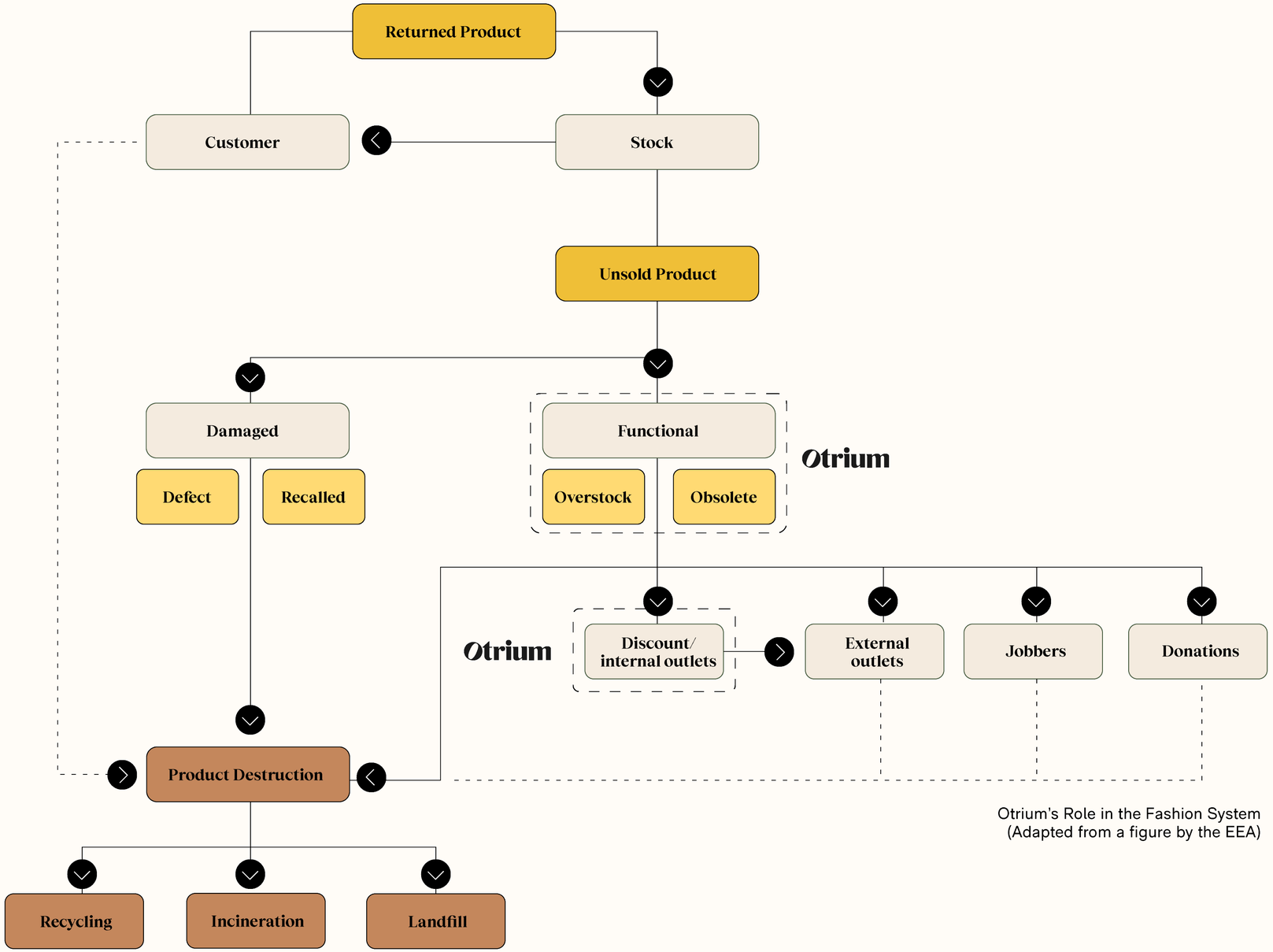
Through partnerships with brands, Otrium not only prevents the wasteful disposal of unsold garments but also avoids additional environmental impacts—including carbon emissions, water, and fossil fuel extraction—by partially avoiding the manufacturing, distribution, use, and disposal of new products.



As brands grapple with global compliance and environmental challenges, Otrium's model not only aligns with the objectives of regulations like the ESPR but also offers brands an alternative revenue stream and a practical route towards participation in the circular economy.

This analysis reveals the critical intersections of compliance, environment, and economic potential, highlighting Otrium's pivotal role within the new regulatory framework.





Otrium's Role in the Fashion System
(Adapted from a figure by the EEA)

Unsold stock: the European landscape

The destruction of unsold and returned textiles remains a critical issue within the European retail landscape. It reflects a broader waste problem and lack of transparency that plagues the fashion industry despite growing consumer awareness and regulatory pressures. This issue highlights the industry's struggle with significant amounts of waste and the sensitive nature of limited disclosure regarding the fate of unsold stock. The resulting opacity not only exacerbates the waste problem but also hinders the sector's ability to fully engage with environmentally conscious practices.

This analysis delves into the current state of textile waste, shedding light on the volumes and treatment of unsold goods. It also explores effective solutions that could drastically reduce this waste, aligning with sustainability goals and consumer expectations.

In the 'Quantifying Otrium's Avoided Impact in 2023' report, Vaayu and Otrium provide new data that aligns with the existing research in Europe's unsold stock space. Using the European Environment Agency (EEA)[5] 'The destruction of returned and unsold textiles in Europe's circular economy' 2024 briefing[6] as a benchmark, Otrium's avoided impact data offers fresh insights into managing unsold stock and demonstrates how innovative solutions can significantly mitigate the ongoing waste issue. Here, we explore how the new insights can serve as a valuable benchmark for the industry, driving forward sustainability goals and reshaping consumer expectations.

5. The European Environment Agency (EEA).

6. European Environment Agency, The destruction of returned and unsold textiles in Europe's circular economy, 2024.

Volume of unsold stock

The EEA underscores the challenges in obtaining data on unsold textiles, with estimates suggesting that around 21% of textile products remain unsold, and approximately 20% of these are eventually destroyed. Ongoing research and more data are crucial. Against this background, the current research by Otrium and Vaayu is especially important, as it addresses the problem with scarce data and reinforces the importance of Otrium's approach in mitigating textile waste.

Unsold stock disposal

The EEA estimated that, annually, 4-9% of all textile products introduced to the European market are destroyed before use, equating to between 264,000 and 594,000 tonnes. The new analysis for Otrium aligns with these figures, revealing that without off-price channels like Otrium, the rate of unsold stock disposal and recycling could be as high as 19% (8% disposed, 11% recycled). However, with Otrium's involvement, these figures were considerably reduced to 4% disposal and 8% recycling. This comparison underscores the significant impact that off-price players have in reducing unsold stock waste and enhancing sustainability in the retail sector.

Returns and refurbishment

According to the EEA, 20% of online clothing purchases in Europe are returned, a rate three times higher than in-store purchases, and 22-43% of these returns are destroyed. This data underscores the importance of Otrium's repair and refurbishment program, which mitigates waste by restoring returned items, combating the high destruction rates, and enhancing sustainability in retail.

Low transparency surrounding the fate of unsold textiles complicates efforts to address these challenges. The data calculated by Vaayu on behalf of Otrium in the 'Quantifying Otrium's Avoided Impact in 2023' report aligns with existing statistics, reinforcing the credibility and reliability of the findings in this analysis. By offering a clearer picture of the unsold stock landscape in Europe, this new analysis increases industry transparency and empowers brands with more robust data.

Together, Otrium and Vaayu are pioneering efforts to reshape the industry's approach to unsold and returned textiles, paving the way towards a more responsible and less wasteful fashion sector.

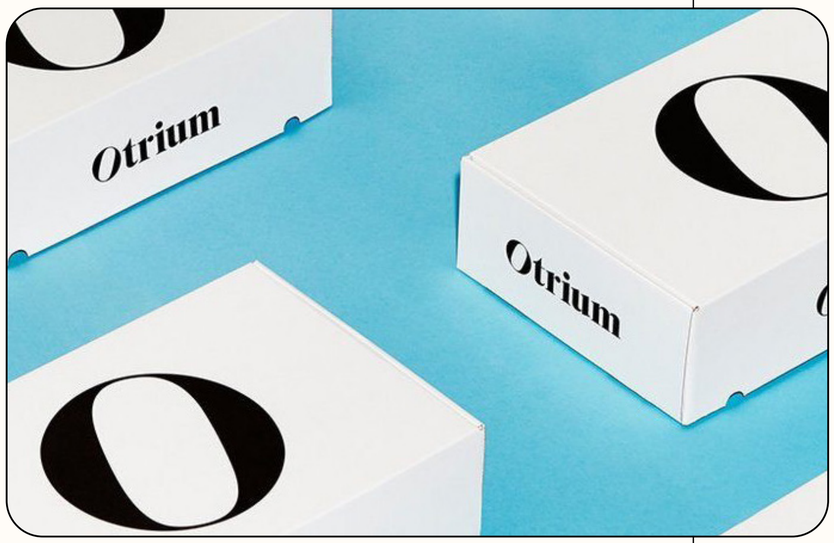
About this research

About this research

For the second consecutive year, Otrium has collaborated with Vaayu to conduct a comprehensive and independent analysis of the environmental impacts associated with its off-price business model. This year's research builds upon the previous analysis by incorporating additional environmental impact categories and refining the methodology to enhance both accuracy and granularity. Otrium's full-company operational impact was taken into account for the calculation of their net avoided impact.

This analysis delves into the significant role off-price and integrity-driven companies like Otrium can have in fostering a circular fashion economy.

It also highlights Vaayu and Otrium's ongoing efforts to enhance the industry's understanding of the life cycle of fashion products. Over the two years, Otrium and Vaayu have continued to iterate and develop one of the largest primary datasets on the management of unsold inventory[7] — contributing valuable insights into sustainable practices with the aim of helping drive the move towards a circular economy.



7. See Wijnia 2016, Avery Dennison 2022 and Fashion Transparency Index 2022 for limited data on unsold stock and waste channels.

Key updates and enhancements

Updates compared to the analysis carried out for the 2022 Impact Report.

Expanded scope and improved granularity:

- This year's analysis includes new metrics, providing a more holistic view of Otrium's environmental impact.
- Data from over 400 fashion brands and approximately 3.6 million fashion products (after returns) were analysed, significantly enhancing the depth and accuracy of the analysis compared to last year's report.

Footwear recycling:

- Delving deeper into the complexities of footwear recycling[8] revealed that while about 1-5% of footwear could theoretically be recycled, large-scale, established recycling processes are not yet prevalent. Most collected footwear is either reused or disposed of through incineration or landfill.

Footwear upcycling:

- Refining the approach to calculating footwear upcycling[9], the methodology moved away from using garment upcycling as a proxy. The upcycling process now includes specific steps such as stitching, replacing shoelaces, and applying paint, with an estimated impact of 1.9 kg CO_2e per upcycled footwear item.

Enhanced data on clothing flows:

- Vaayu incorporated more sources for European clothing flows[10]. These sources provided robust data that aligned well with Vaayu's assumptions on recycling and reuse rates.
- An EEA Briefing[11] indicates a potential ban on the direct destruction of unsold textiles and footwear in the EU, further validating the analysis.

Additional indicators:

- Together, Vaayu and Otrium included abiotic resource depletion and water scarcity as new indicators, enhancing the comprehensiveness of the environmental impact assessment.

Consumer survey for market effects:

- A consumer survey was conducted to better understand market effects, replacing the previous reliance on price information to gauge consumer behaviour and its environmental implications.

8. Analysis conducted based on information via CBI, Diva Portal and Better Shoes Foundation.

9. Approach refined based on information via Paaduks and Murtle.

10. The EEA and Humana, an NGO focused on collecting used clothes.

11. Many returned and unsold textiles end up destroyed in Europe, European Environment Agency, 2024.

Historical context and methodology evolution

Until the inception of this partnership, limited research existed on the environmental impacts of unsold stock practices, including the repair and refurbishment of returns, within the fashion industry. This gap was primarily due to a need for more representative primary data.

Brands typically plan inventory well in advance, leading to stock levels that may not align with actual demand due to unpredictable seasonality, changing fashion trends, and supply chain disruptions. Consequently, products often remain unsold at the end of each season and could be wasted if not managed through off-price business models like Otrium's. This year, Vaayu and Otrium also examined how changes in production can be influenced by the presence of off-price models.

Off-price models can significantly impact production strategies. When unsold products are redirected to off-price channels, these items still reach consumers and satisfy market demand. Without these channels, brands would need to produce new items to meet this demand, potentially leading to overproduction and increased waste.

Overall, off-price business models are critical for balancing inventory levels, aligning production with actual market consumption.

Results

In 2023, by providing brands with a profitable route to dispose of their unsold stock, Otrium avoided:

18,420
tonnes of carbon emissions (CO_2e)

Equivalent to **7,958** return flights for one passenger from Amsterdam to NYC

1,086
tonnes of waste

Equivalent to **1,357,711** new pairs of jeans produced

54
million m3 eq (water scarcity)

Equivalent to the yearly water consumption of **8,656,985** people

892
TJ (abiotic resource depletion)[12]

Equivalent to **544,628,794** mobile phones charged per day[13]

12. Abiotic resource Depletion (fossil) ADPf: The over-extraction of fossil fuels including all fossil resources.

13. Table with detailed results can be found in Appendix 1.

Per purchase[14], these savings equate to:

5.02
kg of carbon emissions (CO_2e)

Equivalent to **40.8** km driven in EU

0.3
kg of waste

Equivalent to **1** new t-shirt produced

15
m3 eq (water scarcity)

Equivalent to the yearly drinking water consumption of **10** people

243
MJ (abiotic resource depletion)[15]

Equivalent to **14** mobile phones charged per day

14. Compared to a hypothetical scenario in which Otrium does not exist and fashion brands have to find other channels to clear their unsold/excess stock.

15. Table with detailed results can be found in Appendix 2.

Otrium's business model resulted in less negative impact:

The avoided emissions from excess stock greatly overshadowed the potential negative effects of data-made products[16].

Data-made items accounted for **5.5%** of transactions but generated only **around 4.6%** of Otrium's total impact with respect to all four categories investigated.

The avoided impact per transaction from excess stock **(-5.4 kg CO_2e)** was significantly higher than the impact created by data-made products at **1.8 kg CO_2e**.

16. Data-made refers to the items that Otrium brand partners produce to be sold on Otrium, utilising data insights provided by the platform.

		Climate Impact (tonnes Co_2e)		
Stock	Transaction Count	Status Quo (Otrium's Operational Impact)	No Otrium (Potential Total Avoided Emissions)	Net Avoided Impact Otrium
Excess	3,455,668	40,899	59,526	-18,627
Data Made	200,571	2,004	1,643	361
Refurbished	10,943	34	188	-154
Total	**3,667,182**	**42,937**	**61,357**	**-18,420**

		Waste (tonnes)		
Stock	Transaction Count	Status Quo (Otrium's Operational Impact)	No Otrium (Potential Total Avoided Emissions)	Net Avoided Impact
Excess	3,455,668	3,842	5,022	-1,179
Data Made	200,571	223	127	96
Refurbished	10,943	6	8	-3
Total	**3,667,182**	**4,071**	**5,157.19**	**-1,086.17**

The amount of avoided impacts varied through product types:

Footwear products are estimated to result in the highest amount of avoided emissions mainly due to the higher impact, on average, of producing footwear. Results indicate an average avoided impact of **6.4 kg CO_2e**, 341 g waste, 3.9 m3 eq of water use, and 554 MJ of nonrenewable resource (fossil) use.

On the other hand, accessories, which have a low manufacturing footprint, can help prevent **0.8 kg CO_2e**, 0.1 m3 eq, and 65 MJ per product.

Garment items purchased through Otrium are estimated to avoid **5.1 kg CO_2e**, 341 g waste, 17 m3 eq water use, and 214 MJ nonrenewable resource (fossil) use.

Reducing emissions through end-of-life management:

Findings indicate that a purchase from Otrium results in avoided impact compared to each of the alternative pathways included in this research. The downward bars in the figures on the following page show the estimated impact per pathway and as shown, the highest amount of impact reduction per item can be obtained from diverting brand and outlet excess stock from stock buyers, gifting/selling to employees, and upcycling to Otrium. The best alternatives, if excess stock is not sent to Otrium, on the basis of the four impact categories investigated, are donating to charity, disposing of the stock directly, or recycling the item.

On the other hand, considering the likelihood of brands diverting excess stocks to alternative pathways, the largest proportion of avoided emissions (CO_2e) overall stemmed from the prevention of disposal, the avoidance of selling or gifting to employees, and the avoidance of sales to stock buyers.

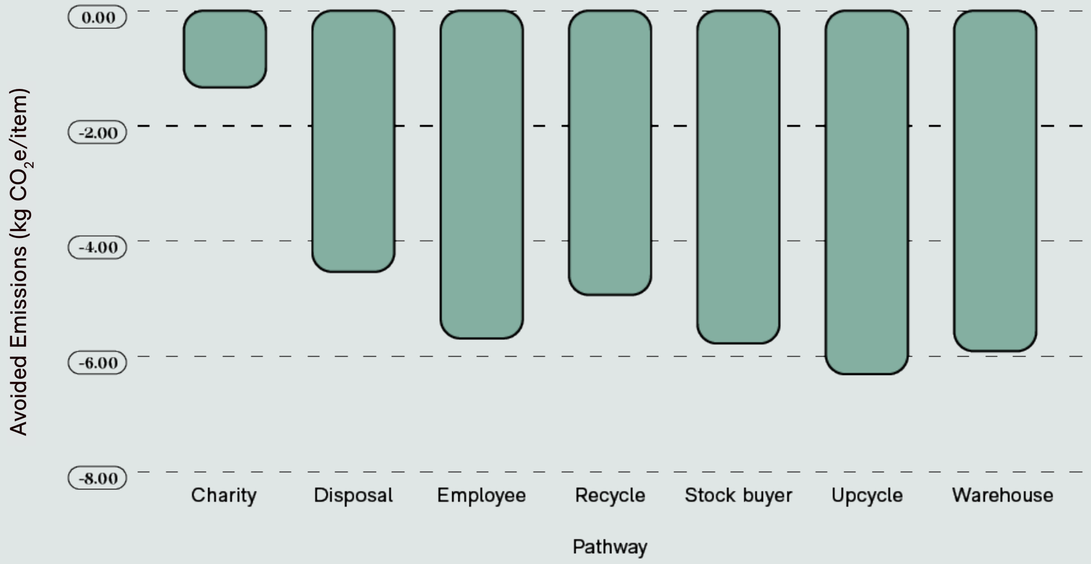
- **2,436 tonnes CO_2e** avoided by prevention of disposal
- **7,083 tonnes CO_2e** avoided by prevention of employee gifting
- **5,942 tonnes CO_2e** avoided by prevention of sale to stock buyers

A comparison of total avoided impact per pathway and per impact category after considering the likelihood of brands diverting their excess stock to each alternative is shown in the table below.

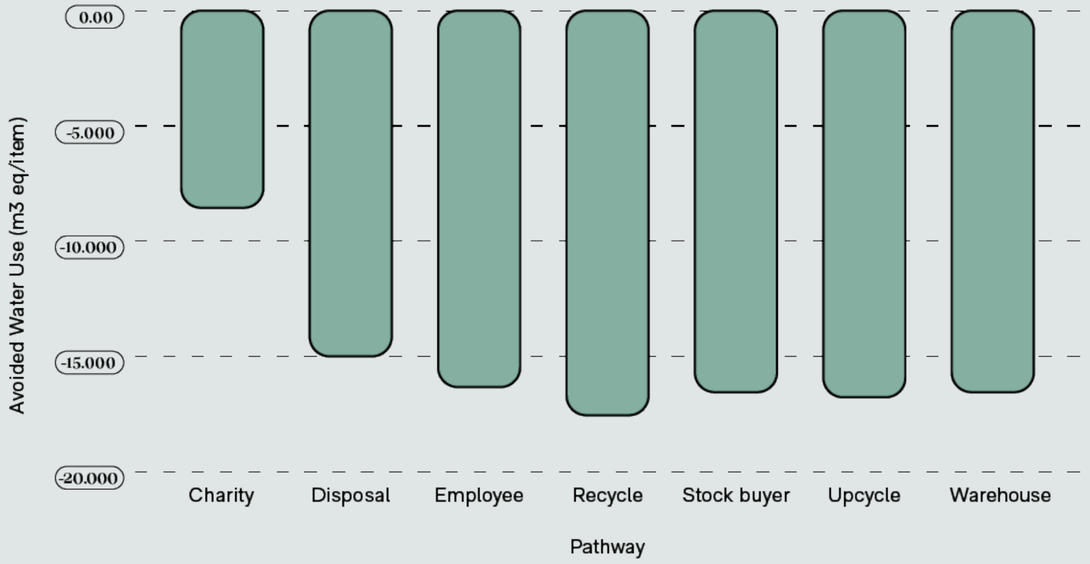
By leveraging the consequential LCA approach and considering the flow of fashion items at the system level, it becomes evident that without off-price fashion platforms, the demand for items (which would have otherwise been sold to stock buyers or landfilled, for example) would necessitate the production of new items. The following estimates take system-wide change into account.

Impact Category	Charity	Disposal	Employee	Recycle	Stock buyer	Upcycle	Warehouse
Climate Impact (kilotons CO2e)	-0.1	-2.4	-7.1	-1.6	-5.9	-0.7	-0.8
Water (million m3 eq)	-0.4	-8.0	-20.2	-5.6	-16.9	-2.0	-2.1
Waste (tons)	-4.1	-205.8	-421.8	-92.9	-371.2	-35.7	-48.1
ADP (TJ)	-5.7	-141.3	-331.5	-78.6	-277.5	-32.6	-34.9

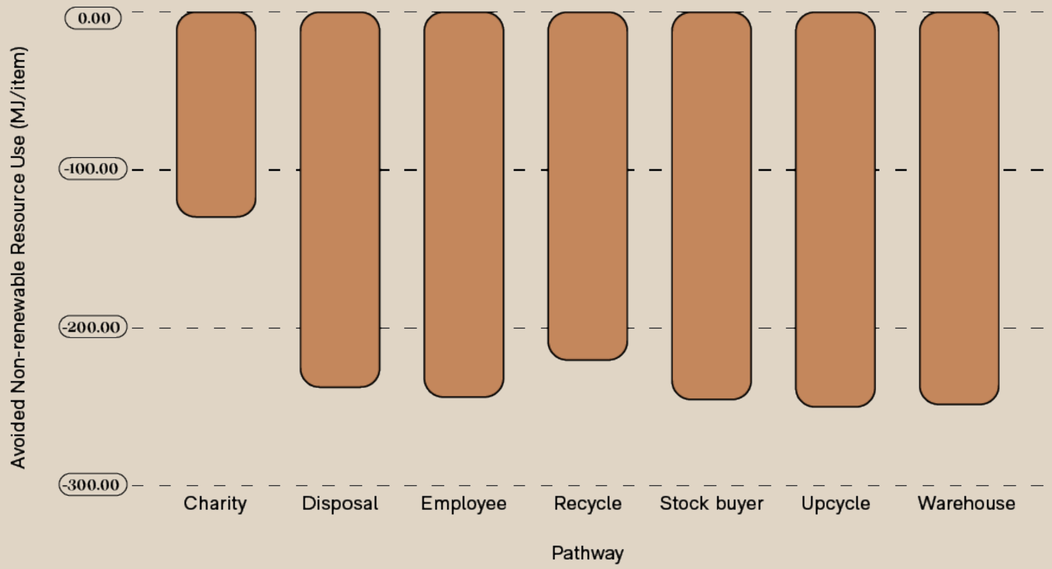
Avoided Climate Impact per Pathway



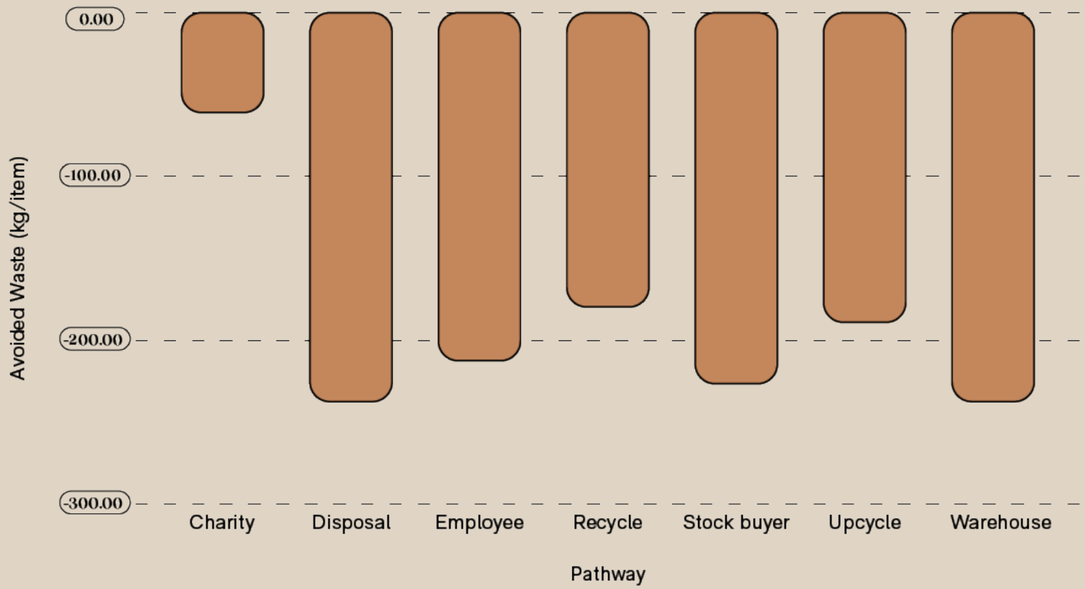
Avoided Water Use by Alternative Pathway



Avoided Non-Renewable Resource (Fossil) Use by Alternative Pathway



Avoided Waste by Alternative Pathway



Methodology

Methodology

Goal

The main goal of the research was to estimate the avoided carbon emissions, water scarcity, abiotic resource depletion and waste of Otrium's off-price business model, which connects customers to unsold stock from fashion brands.

To achieve this, the analysis focused on quantifying the environmental benefits of extending the life cycle of fashion items that would otherwise go unsold. This included examining the avoided environmental impacts of various end-of-life scenarios such as disposal, gifting to employees, and selling to stock buyers.

By leveraging the consequential LCA approach, the analysis sought to provide a comprehensive understanding of how off-price platforms contribute to sustainability by reducing the need for new production and mitigating waste.

An important aspect of this research was analysing Otrium's innovative garment refurbishment program, which targets damaged returns. Launched in collaboration with Bleckmann and The Renewal Workshop, this program is designed to reintegrate damaged garments back into the market, further reducing waste and emissions. While not the core focus of this analysis, it was included because the initiative illustrates the broader potential of sustainable practices within the fashion industry.

Additionally, the analysis aimed to provide Otrium with detailed avoided environmental impact estimates at both the product and brand levels. These insights, provided by Vaayu, will support Otrium's B2C and B2B communication efforts, helping to highlight the environmental benefits of their business model to customers and brand partners alike.

Scope

The off-price sector primarily operates two business models:

1. Selling unsold new stock — selling unsold stock from brands at a significant discount versus the original retail price, including close-out and excess stock from made-for-outlet collections.
2. Producing new items — producing products directly for off-price or ‘outlet’ stores (data-made fashion).

Otrium operates both models, but in line with its mission to reduce industry waste, excess stock accounts for a much higher proportion of sales than is typical for off-price. The industry average range of excess stock sold is estimated to range between 25-60%[17], compared to 90% at Otrium.

Otrium also has a third offering:

3. Refurbished returns — Otrium’s service to recondition and resell damaged items that have been returned.

In line with Otrium’s offering, all three models were included in the scope of the analysis[18].

The methodology occasionally uses ‘off-price’ as a proxy for Otrium. To ensure fair and representative results for Otrium, the difference in the percentage share of the two main business models described above was modelled for Otrium versus the broader off-price sector and accounted for within the overall calculations.

In line with a consequential LCA approach, broader market rebound effects were also accounted for, such as the potential change in consumer demand driven by discounting. This was measured using the Replacement Rate, with the methodology described in the Approach section below.

17. Based on proprietary Otrium sales data, secondary research and anecdotal experience from former off-price buyers.

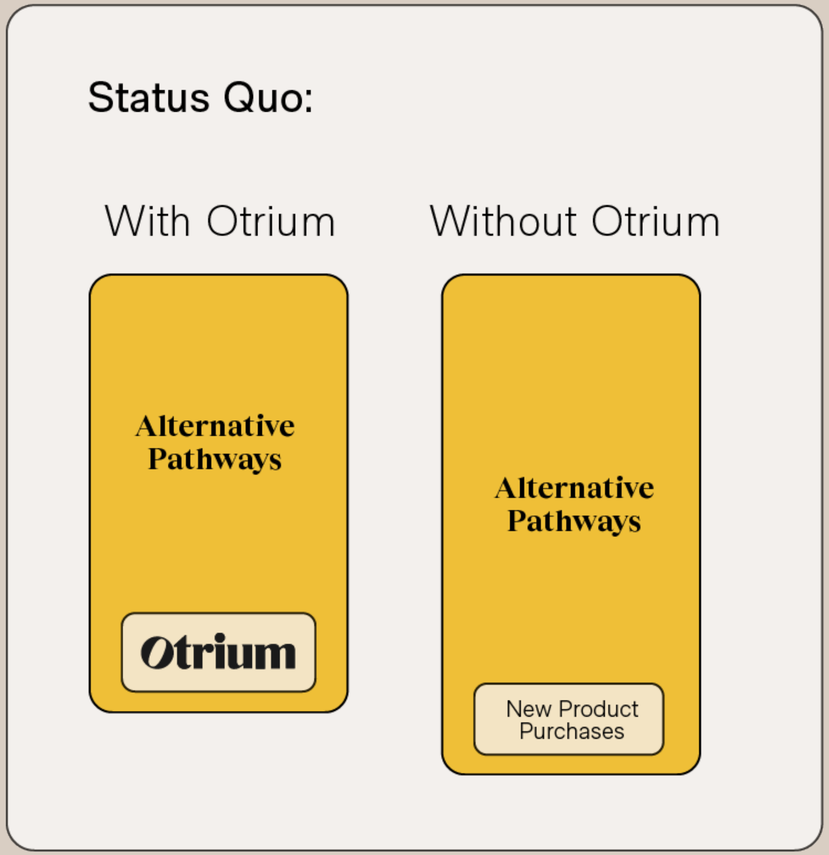
18. Another model, ‘gated sales’ (brands selling excess stock directly to their employees) was excluded, as it is only in the testing phase.

Approach & outcomes

Fashion brands use multiple methods to clear the unsold/excess stock left over at the end of each season. Some partner with off-price businesses like Otrium, while others may use other resale channels, donate to charities, or dispose of the goods directly. The decision depends on various factors, including time, cost, item quality, and existing waste regulations.

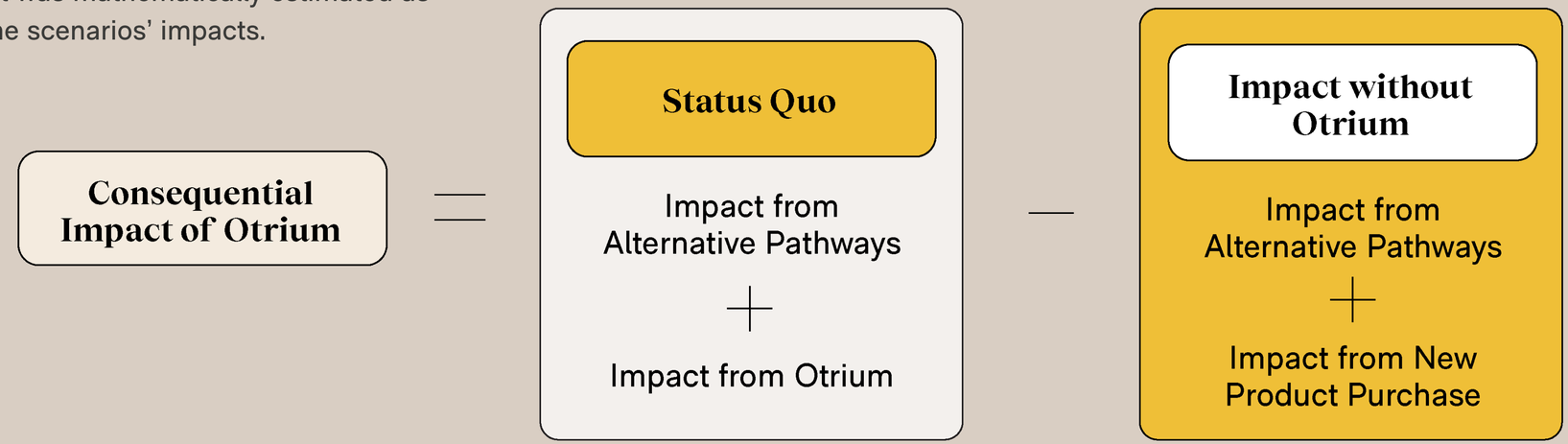
To reflect this, the research employed elements from consequential LCA[19] to quantify the change in emissions and waste within the broader fashion system. Consequential impacts of excess stock were approximated by comparing the status quo, the baseline pathway that includes Otrium, to multiple scenarios in which Otrium does not exist, and fashion brands use alternative channels to clear their excess/ unsold stock in these alternative pathways.

The figure on the right helps to illustrate the difference between these two scenarios. As shown, in the status quo, unsold stock from brands can end up at Otrium or alternative pathways.



19. A method that estimates comparative impacts (such as carbon emissions) as the total, system-wide change that results from a given decision or intervention.

The consequential impact was mathematically estimated as the difference between the scenarios' impacts.



Three main changes were considered in the consequential LCA model. These are:

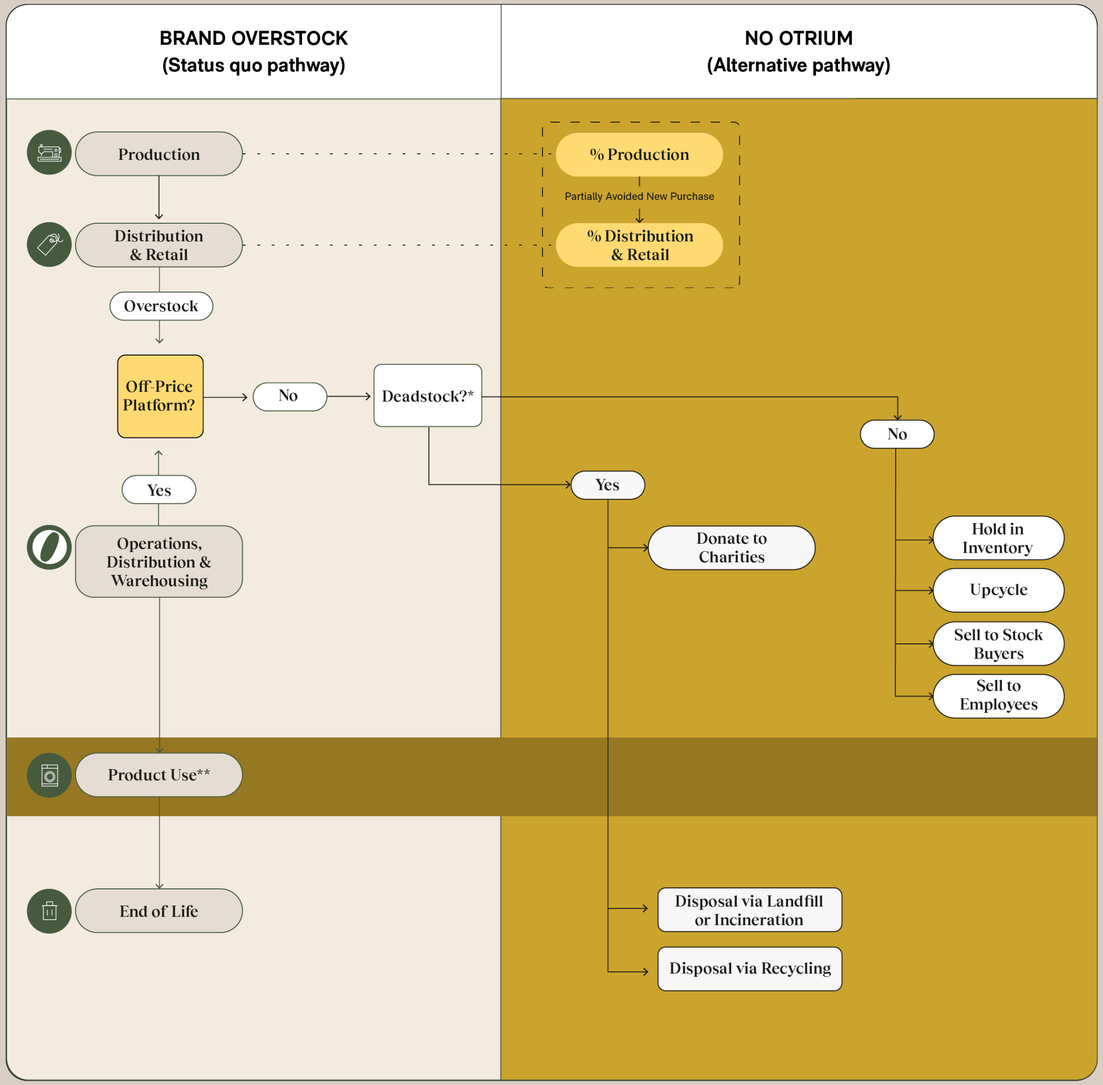
1. Change in the flow of unsold stock (i.e., unsold stock that would have landed at Otrium had to be diverted to the alternative pathways)
2. Production of new products that Otrium purchases (in the status quo) replaced
3. Rebound effect of selling the products at a reduced price

The total amount of unsold items remains the same in both scenarios, but the flow profile to the alternative pathways changes. Moreover, the Otrium purchase in the status quo is met by purchase elsewhere in the 'no Otrium' scenario, driving demand for new products. The demand for new products was estimated as the number of Otrium purchases that replaced the planned purchase of a similar product. This was quantified through the use of a Replacement Rate (i.e., the rate at which a purchase from Otrium replaced a new product purchase). The Replacement Rate was estimated through a consumer survey. Thirdly, the effect of reduced selling price was also taken into consideration. This was mainly estimated in the case of the data-made stock, which is a new product demand driver. To estimate the rebound effect, a regression analysis was performed in last year's research on price and demand data to estimate the change in demand in relation to price change. From this, it was estimated that, on average, an item results in 18% rebound effect (i.e., purchases are higher by about 18% than what they would have been at the regular sales price). No rebound effect was estimated at the system level on excess and refurbished stock because these stocks are not new product demand drivers.

However, rebound effect and overconsumption may ensue in the form of unplanned purchases influenced by reduced prices, access to good brands, or overall better product purchase deals.

The extended system boundary and details on the alternative pathways are further illustrated in the figure on the right.

System Overview of Alternative Pathways



Extended System Boundary
(See ISO 14049 and WRI)

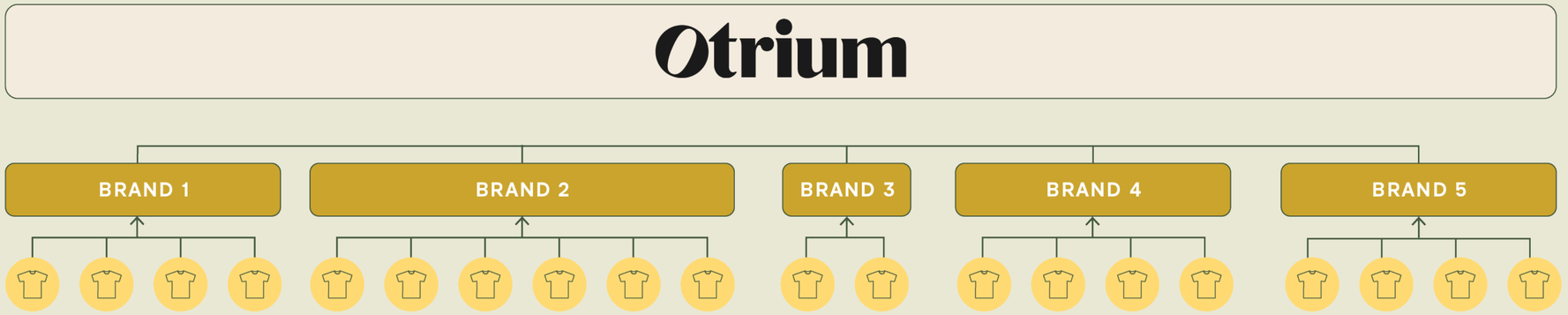
*Deadstock is defined as products that could not be sold at full or sale price and have either been i) written off from the company's inventory or ii) have remained in stock in a warehouse for more than three years[20].

**Product use was excluded from the scope of the analysis

20. Draft EU PEFCR for Apparel and Footwear v1.3, Quantis (March 2022): "The deadstock definition used in this PEFCR is the French deadstock definition (Décret n°2020- 1610 1724): products that could not be sold in traditional sales channels, or through discount sales or private sales. Items that could not be sold are defined as items that have either been written off from the company's inventory, or have remained in stock in a warehouse for more than 3 years."

The consequential impacts on a per-product level were estimated based on the system model presented above. They were based on the likelihood and resulting impacts of brands using alternative stock clearance pathways in the absence of Otrium and then expanded to quantify the impact at brand[21] (supplier) and total Otrium level, as shown below:

Overall approach



The estimated avoided carbon and waste on a per product level was calculated as follows[22]:

Net Avoided Environmental Impact per Product = **Environmental Impact from Sale via Otrium** - **Impact of Replaced New Product Purchase** + **Emissions from Market Rebound Effects**

21. Brand-level estimates are modelled using Otrium sales and stock data and representative survey responses from 41 fashion brands including information on size, segment and typical unsold stock practices.

22. See Appendix 7 for detailed calculations.

The process consisted of:

1. Calculating the environmental impact from the status quo of selling via Otrium to generate a representative baseline[23].
2. Calculating the impacts of alternative stock clearance pathways[24].
3. Calculating impacts of replaced new products
4. Including the additional impacts generated by indirect market rebound effects[25] to account for broader changes within the system, such as additional purchases driven by discounting[26].

Finally, the consequential impacts were derived by multiplying the per-product/pathway impact by the likelihood of brands using other stock clearance pathways in the absence of Otrium (e.g., whether environmental impact increased or decreased) based on survey responses from fashion brands about their unsold stock practices.

23. Based on the draft EU PEFCR for Apparel and Footwear v1.3, Quantis (March 2022), product data provided by Otrium and emissions data from Vaayu's proprietary Carbon Modelling Engine.

24. Using a range of data from secondary literature, listed in Appendix 7.

25. Changes in market size that occur over and above any changes in market share, and changes in the market price of inputs. See Maxwell, Owen, McAndrew, Muehmel, and Neubauer, 2011.

26. Based on statistical analysis of primary sales data and additional secondary research.

Status quo impacts

Status quo: Carbon emissions, water scarcity, abiotic depletion, and waste from sale via Otrium

Almost 5 million fashion products were sold by Otrium in 2023. Although Otrium acts as a reseller, the products are new and, therefore, have a carbon and waste footprint.

In order to estimate the impact of selling products via Otrium (the status quo baseline), the footprint per sold product was calculated based on:

- The draft EU Product Environmental Footprint Category Rules for Apparel and Footwear
- Primary data provided by Otrium
- Emissions data from Kria, Vaayu's Impact Modeling Engine and Database (proprietary product carbon footprinting technology).

This was done within the system boundaries outlined below:

- Raw material extraction
- Material manufacturing
- Wet treatments
- Product manufacturing and assembly
- Distribution and warehousing activities at the partner brands
- Warehousing activities at Otrium, including:
  - Electricity required for warehousing
  - Additional transport for some product returns (~55% of all outbound)
  - 'Polishing' of items (e.g. steaming and repacking)
  - Refurbishing activities for damaged returns (~0.75% of all returns)
- Distribution until the final customer
- End-of-life

The focus of the analysis was the comparative analysis of selling products through Otrium versus an alternative scenario in which Otrium does not exist, and brands use other channels to dispose of unsold stock. The impact that comes from laundering (or other use phase inputs, depending on the product) during product use was considered equal in both. In a comparative analysis, these equal impacts cancel each other out.

Product data analysed

Product type

Product size (weight)

Material composition

Fabric construction and type

Country of origin

Country of sale

Accounting for refurbished returns

As part of its service offer, Otrium also refurbishes selected products that are damaged upon return and resells them to consumers. This equates to around ~0.75% of all returned items[27]. Because the damaged items are repaired and resold instead of disposed of, the refurbishing process essentially lowers the carbon and waste footprint per product by lowering the waste generated[28]. The impact of refurbished returns was also calculated separately as avoided emissions at the level of Otrium as a whole.

27. Based on a return rate of 34.5% in 2023 (compared to an industry average of ~50%). An estimated 2-2.25% of returned items were damaged, out of which, 33% (or 0.75% of all returns) were refurbished and made available for sale. The remaining items that could not be sufficiently repaired were sold to stock buyers.

28. The emission savings equates to the cradle-to-gate and end-of-life impact of the damaged items, minus those generated by the refurbishing process such as sewing buttons, steaming, and transport.

Alternative pathways impacts

Alternative pathways: Carbon emissions, water, abiotic depletion, and waste if Otrium did not exist

Following a consequential LCA approach, the carbon emissions and waste of selling products via Otrium (the status quo baseline) were then compared against a set of hypothetical alternative pathways, in which Otrium does not exist, and fashion brands have to find other channels to clear their unsold/excess stock.

Furthermore, in the absence of Otrium, it was assumed there would be a need to produce new items to satisfy market demand, further exacerbating environmental impacts and complicating inventory management.

Exploring seven alternative pathways

In the status quo pathway, a customer is looking for a product (e.g., a T-shirt) that they find and buy on Otrium. This item is typically excess/unsold stock that has already been produced from/by a brand.

In the alternative pathways, the item would not be sold via Otrium but either resold via other channels, donated, or disposed of.

In total, seven possible alternative pathways were explored:

1. Holding the stock in inventory for eventual resale
2. Upcycling the stock for eventual resale
3. Selling the stock to other 'stock buyers[29]'
4. Selling the stock to employees
5. Donating the stock to charities
6. Disposing of the stock via landfill or incineration
7. Disposing of the stock via recycling

The status quo scenario was compared to all seven alternate scenarios to calculate the potential for avoided emissions and waste.

An important consideration was that, in these cases, an item wouldn't be available for a customer to buy, which would result in the purchase of a different (new) item elsewhere.

From this perspective, Otrium can be understood to be avoiding the environmental impacts associated with the disposal of the original item, as well as (partly) avoiding the environmental impact generated by the manufacture and distribution of the additional new item.

As such, the assessment not only captures the impact of averting items from landfills and incineration but also the benefits of not needing to produce new items to satisfy customer demand.

29. Actors without branded, consumer-facing retail outlets that resell second-hand stock.

Environmental impact of the rebound effect

To enable a more holistic assessment of Otrium's indirect impacts, the impact generated by the rebound effect[30] of selling products at a lower price was also included. For example, customers may be encouraged to buy more than they need or were initially looking for because they consider a product a good deal with limited availability. More purchases result in more emissions and waste, which 'cancels out' some of the emissions and waste otherwise avoided by Otrium.

For excess stock, it was assumed that the existence of Otrium did not influence the brands' current production of new clothing, since orders are primarily based on future sales volumes and growth targets, overstock is less profitable and therefore not intentionally planned, and emerging technology and business models (e.g., on-demand production) are still in their infancy.

For data made stock (i.e., new production of bestselling styles[31]), better supply and demand matching leads were assumed to lead to 0% deadstock. This was in line with current practices at Otrium[32] and a lack of other reliable market data. However, lower retail prices may increase purchases (i.e., rebound).

30. The analysis reflects a snapshot in time, based on sales and stock data from 2023. It does not measure future effects, which should be modelled separately based on a specific decision or intervention. Proxies were used in the absence of detailed consumer behaviour data, which could be included in future iterations.

31. Referred to internally by Otrium as 'data-made'.

32. Where any unsold new production is subsequently sold to other stock buyers.

Estimating the rebound effect and Replacement Rate

In the previous year, the approach to estimating the rebound effect relied heavily on regression modelling and secondary data, primarily utilising demand price elasticity to gauge overconsumption. This method assumes that price was the sole driver of increased consumption on off-price platforms, which, while significant, does not account for other factors, such as enhanced access to brands through discounts.

This year, the methodology was refined by conducting a direct survey with Otrium's users across key markets, including the Netherlands and Belgium. This survey aimed to provide a more accurate estimate of the rebound effect by directly capturing consumer behaviour and motivations. A total of 4,876 responses were collected from Germany and the Netherlands.

To estimate the increase in consumption due to discounting, the survey included a key question: "*Buying this item from Otrium prevented me from buying another new (similar) item*." Respondents were asked to rate their agreement with this statement on a scale from 1 to 6, ranging from "Fully agree" to "I don't know". Responses that did not agree with the statement were considered indicative of overconsumption that would not have occurred otherwise.

The survey results revealed a relatively low Excess Purchase Rate (EPR) of 11.8%, indicating that for every eight items sold on Otrium, one additional item was purchased. This implies that 88.2% of purchases on Otrium displaced the need for a new item, compared to last year's estimate of 82%, which was based on demand price elasticity.

Consumer surveys offer a more nuanced understanding of additional purchases than demand price elasticity, as they consider various consumer motivations beyond price. This approach acknowledges that discounts not only drive purchases but also enhance accessibility to brands, influencing consumer behaviour in ways that demand price elasticity cannot fully capture. Therefore, the current methodology, which relies on direct consumer feedback, provides a more accurate and comprehensive estimate of the rebound effect associated with off-price platforms like Otrium.

This refined methodology not only aligns with the latest regulatory expectations but also enhances Otrium's ability to sustainably manage unsold inventory, reinforcing its commitment to reducing environmental impact.

Alternative stock clearance pathways

A survey was conducted between March and April 2024 with support from Otrium to gather representative primary data from fashion brands regarding their unsold/ excess stock practices. The survey was sent to Otrium's existing brand partners and also shared with fashion industry groups and other relevant public forums[33] to ensure a representative and statistically relevant sample size. In total, 41 responses were collected, with 17 responses that included insights about brands' unsold stock practices. The responses were used to inform the avoided emissions and waste estimations for each alternative pathway, as well as the brand-level avoided emissions and waste estimations that will be shared with Otrium's brand partners.

The survey asked questions related to the following topics:

- Company type and size
- Segment (luxury, designer, premium, trend-focused, value)
- Brand identity (affordable, conscious[34], trendy, luxurious, timeless)
- Unsold stock practices (stock type, quantity, age, traceability)
- Use of other alternative channels to clear stock

The probability of brands selecting alternative methods for clearing excess inventory without Otrium was assessed through primary survey responses and insights from secondary literature. Brands were queried about their existing strategies for managing unsold stock and their likely actions if off-price platforms like Otrium were unavailable. These responses were utilised to estimate the reductions in carbon emissions and waste by comparing the likelihood of different clearance pathways ('status quo' versus 'no Otrium')[35]. This analysis helped calculate the net impact on carbon emissions and waste reduction.

FY2023 Pathway probabilities for two scenarios: Status quo and No Otrium (FY2022 values are in parenthesis)

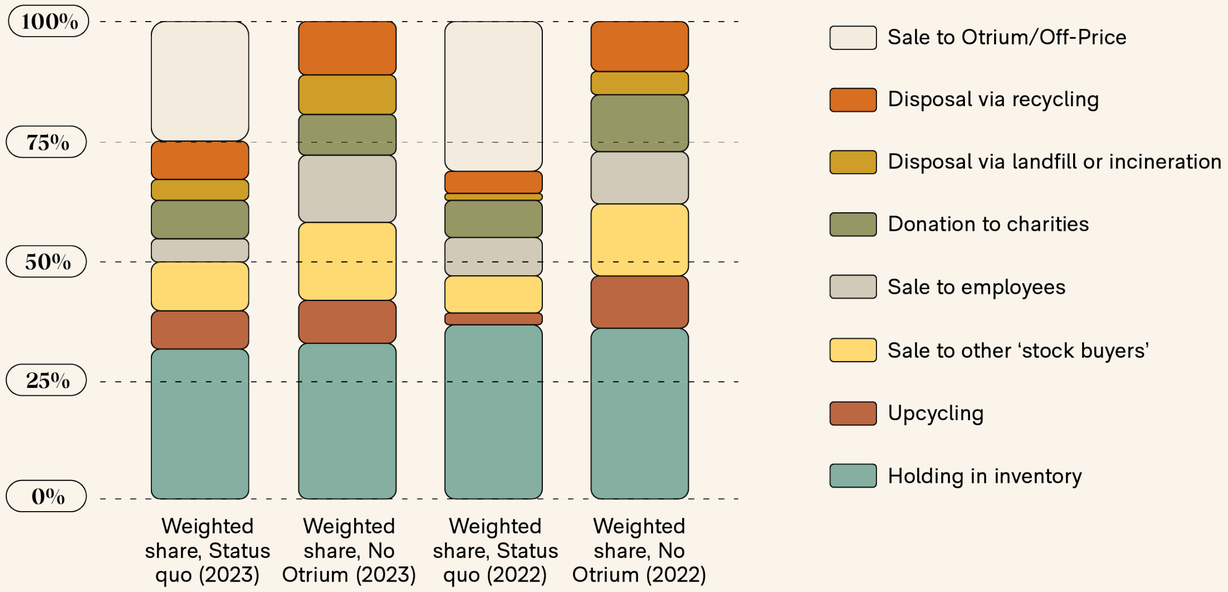
Pathway	Weighted share, Status quo	Weighted share, No Otrium	% Change (D_{path})	Probability by pathway, Otrium stock	*Avoided carbon* (t CO_2e)	*Avoided waste* (t)	*Avoided water* (million m3)	*Avoided abiotic resource depletion* (TJ)
1. Holding in inventory	32% (37%)	33% (36%)	1%	4% (-2%)	754	48.1	2.1	34.9
2. Upcycling	8% (2%)	9% (11%)	1%	4% (28%)	739	35.7	2	32.6
3. Sale to other 'stock buyers'	10% (8%)	17% (15%)	7%	28% (23%)	5,871	371.2	16.9	371.2
4. Sale to employees	5% (8%)	14% (11%)	9%	36% (9%)	6,998	421.8	20.8	331.5
5. Dontation to charities	9% (8%)	9% (12%)	0%	0% (12%)	54	4.1	0.4	5.7
6. Dontation via landfill or incineration	4% (1%)	8% (5%)	4%	16% (14%)	2,407	205.8	8	141.3
7. Dontation via recycling	8% (5%)	11% (10%)	3%	12% (16%)	1,579	92.9	5.6	78.6
(Sale to Otrium/)	25% (31%)	–	–	–	–	–	–	–

33. Shared by Vaayu and Otrium on LinkedIn and with relevant LinkedIn groups related to sustainability in fashion.

34. Based on Otrium's own internal definition.

35. Referencing the most likely scenario, taking into account the uncertainties in the model.

The pathway flow probabilities from the above table can be visually represented as follows:



Focusing on results for 2023, significant pathway probability change can be observed for 'Sale to other stock buyers' and 'Sale to employees'. About 64% of what would have flown to Otrium was diverted to these two pathways in the 'no Otrium' scenario. Meanwhile, almost 28% are disposed of, with about 16% diverted to 'Disposal via landfill or incineration' and 12% to 'Disposal via recycling.' Around 8% was diverted equally to 'Upcycling' and 'Held in inventory.'

This profile was quite different from findings in the previous year (2022), especially in the case of how much was diverted to upcycling, sale to employees, and donation to charities. Survey results from last year indicate that the tendency for brands to upcycle more and donate to charities would have been higher. Selling or giving the overstock to employees was a less popular option based on last year's results.

This consequently influences the results, with the largest proportion of avoided emissions coming from the prevention of disposal, the avoidance of selling or gifting to employees, and the avoidance of sales to stock buyers.

Appendix

Appendix 1: Avoided Emissions Results - Total Otrium

		Climate Impact (tons Co_2e)		
Stock	Transaction Count	Status Quo (Otrium's Operational Impact)	No Otrium (Potential Total Avoided Emissions)	Net Avoided Impact Otrium
Excess	3,455,668	40,899	59,526	-18,627
Data Made	200,571	2,004	1,643	361
Refurbished	10,943	34	188	-154
Total	**3,667,182**	**42,937**	**61,357**	**-18,420**

		Waste (tons)		
Stock	Transaction Count	Status Quo (Otrium's Operational Impact)	No Otrium (Potential Total Avoided Emissions)	Net Avoided Impact
Excess	3,455,668	3,842	5,022	-1,179
Data Made	200,571	223	127	96
Refurbished	10,943	6	8	-3
Total	**3,667,182**	**4,071**	**5,157.19**	**-1,086.17**

		ADP, fossil (TJ)		
Stock	Transaction Count (after returns)	Status Quo	No Otrium	Avoided Impact
Excess	3,455,668	1,081.11	1,983.26	-902.15
Data Made	200,571	62.75	47.17	15.58
Refurbished	10,943	0.38	6.28	-5.90
Total	**3,667,182**	**1,144.24**	**2,036.71**	**-892.47**

		Water Scarcity (million m3 eq)		
Stock	Transaction Count (after returns)	Status Quo	No Otrium	Avoided Impact
Excess	3,455,668	81.64	136.75	-55.11
Data Made	200,571	4.74	3.51	1.23
Refurbished	10,943	0.03	0.43	-0.41
Total	**3,667,182**	**86.40**	**140.69**	**-54.29**

Appendix 2: Avoided Emissions Results - per Item

		Climate Impact (kg CO_2e)		
Stock	Transaction Count (after returns)	Status Quo	No Otrium	Avoided Impact
Excess	3,455,668	11.8	17.2	-5.4
Data Made	200,571	10.0	8.2	1.8
Refurbished	10,943	3.1	17.2	-14.1
Total	**3,667,182**	**11.7**	**16.7**	**-5.02**

		Waste (kg)		
Stock	Transaction Count (after returns)	Status Quo	No Otrium	Avoided Impact
Excess	3,455,668	1.1	1.5	-0.3
Data Made	200,571	1.1	0.6	0.5
Refurbished	10,943	0.5	0.8	-0.2
Total	**3,667,182**	**1.1**	**1.4**	**-0.3**

		ADP, fossil (MJ)		
Stock	Transaction Count (after returns)	Status Quo	No Otrium	Avoided Impact
Excess	3,455,668	313	574	-261
Data Made	200,571	313	235	78
Refurbished	10,943	35	574	-539
Total	**3,667,182**	**312**	**555**	**-243**

		Water Scarcity (m3 eq)		
Stock	Transaction Count (after returns)	Status Quo	No Otrium	Avoided Impact
Excess	3,455,668	24	40	-16
Data Made	200,571	24	17	6
Refurbished	10,943	2	40	-37
Total	**3,667,182**	**24**	**38**	**-15**

Appendix 3: Research scope

Table 1: Business models accounted for in the scope of the analysis

Model	Description	In scope?	Rationale
'Excess' stock	Selling existing excess or 'close-out' stock from brands at a significant discount versus the original RRP.	**Yes**	Represents the majority of Otrium's sales.
'Data-made' stock	Producing new items specifically for the Off-Price market based on bestselling styles, sold at a lower price.	**Yes**	Represents a significant part of Otrium's sales.
Refurbished returns	Refurbishing and reselling damaged returns (~2.5% of ~39% returned items).	**Yes**	Modelled as part of the existing product system flow.
Gated sales	Selling existing excess stock exclusively to employees at a discount.	**No**	Included in alternative scenarios for excess stock but not calculated separately. Not part of the original research scope but can be included in future research.

Table 2: System effects accounted for in the scope of the analysis

Effect	In scope?	Rationale
Otrium's comparative impact versus the broader Off-Price sector	Yes	Modelled using a sensitivity analysis, based on business model scenarios in the ratios of 93% excess stock: 7% new items, 60% excess stock: 40% new items and 25% excess stock: 75% new items.
Otrium offering greater value and transparency (to sell excess stock	Yes, indirectly	This may lead to brands preferentially choosing Otrium over other channels/Off-Price businesses and customers paying a higher final sale price (with lower discount rate). A higher sale price and lower discount rate results in fewer excess purchases, meaning a higher Replacement Rate and therefore more avoided emissions for Otrium. This effect is only partially modelled for Otrium, which took into account different stock types but not the final sale pricing at other Off-Price businesses.
Change in amount of waste for 'excess stock'	Yes	Modelled through alternative scenarios, see Approach, Alternative Pathways Impact.
Change in consumer demand driven by Off-Price (discounted) model	Yes	Modelled for both excess stock and new production, see Approach, Rebound Effect Carbon and Waste.
Change in amount of waste for new production from bestsellers ('data-made')	Yes, partially	This estimation is only made for the excess purchases caused due to discounts. The deadstock or overstock rate is assumed to zero for data made items. These rates are not compared with the current market numbers.
Change in the amount of waste produced/saved by the market	Yes	The net amount of waste generated/saved is calculated for each pathway. See Approach.
Change in amount of waste produced/saved due to Extended Producer Responsibility regulations	Yes, indirectly	It is assumed that survey responses will, to some extent, reflect brands' practices based on existing regulation. Future developments are out of scope for this type of analysis.
Change in emissions from transport/warehousing	Yes	Additional warehousing at Otrium is included in the product carbon emission estimations. Wherever relevant, transport and warehousing is also taken into account for each alternative pathway in the hypothetical scenario that Otrium doesn't exist.
Change in recycling of excess inventory	Yes	Included in the alternative scenarios, modelled using survey data and secondary literature on recycling rates.
Change in higher price items replacing cheaper (lower-quality) items	No	Not observed in academic literature. Could be included in future research.
Impact of sustainably-minded consumer	No	Excluded due to previous consumer survey responses, which show price/accessibility as the main drivers for shopping on Otrium. Could be included in future research.
Change in level of future inventory (either reduction through better demand matching or increase due to Off-Price encouraging excess stock)	No	It is not possible to accurately measure future effects with the approach shown above. Currently, it is assumed that Otrium does not influence brands' order volume of new clothing, as i) new orders are planned based on the previous year's sales and company growth targets (not excess stock), ii) brands' forecasting abilities are poor, and iii) emerging business models such as on-demand production are still negligible.

Appendix 4: Methodology updates

This section provides a detailed examination of the modifications made to the modelling of end-of-life pathways compared to the 2022 analysis. It delves into the specific changes implemented to help better understand the improvements and refinements made.

Per pathway:

- Hold in inventory:
  - No change was made in the pathways
- Upcycling:
  - Clothing upcycling pathway is kept the same
  - Footwear upcycling pathway is modelled specifically for footwear this time around. Find the assumptions above
- Selling to other stock buyers:
  - No change was made to the pathways. Research shows that stock lot buyers in Europe deal with surplus clothes and liquidated stock, and they resell them through various channels:
    - **Discounted Retail:** They might sell the clothes to discount retailers who cater to bargain shoppers. These stores can be physical locations or online retailers.
    - **Export:** Sometimes, the clothes are exported to other countries where there's a demand for discounted or specific styles.
    - **Independent sellers:** They may sell the clothes to independent sellers who run their own online stores or market stalls.
    - **Outlet stores:** Stock lot buyers could also sell to outlet stores of major brands that specialise in selling past-season or excess merchandise at a reduced price.
  - However, no specific research is available. There is a need for a detailed report looking into this separately, like this one on charities.
- Selling to employees:
  - No change is required
- Donating to charities
  - No change is required as no big updates from last year's research found
- Disposing via landfill or incineration
  - No change is required as well
- Disposal via recycling
  - The recycling % and type of recycling are not changed as well.
  - For garments, the numbers align well with the new research found

Appendix 5: Refurbished returns calculation: Assumptions

Important Assumptions:
1. Electricity used in the renewable mix, in line with Otrium warehouses
3. Further, it is assumed that 25% of items are not saved even after refurbishing and are disposed
4. System boundaries of emission savings is manufacturing + distribution + end-of-life (EOL) as per PEFCR guidelines

% saved calculations:
85% of returns are faulty, or 15% don't have anything wrong with them
75% of items are put back in stock
49% of items that are in textile containers are actually reused. The rest are disposed of or recycled. So, it is assumed if not for repairs, these would end up in textile containers, where 51% would be disposed

Appendix 6: Replacement Rate result

Survey Results Breakdown:

Survey Question:

"Buying an item at Otrium prevents me from buying a new (similar) item."

- Fully agree
- Somewhat agree
- Neutral
- Fully disagree
- Somewhat disagree
- I don't know

Replacement Rates:

Germany (DE):

- Garments: 0.83
- Footwear: 0.85
- Overall: 0.83

Sample: Garments (1824), Footwear (155), Overall (2047)

Netherlands (NL):

- Garments: 0.92
- Footwear: 0.91
- Overall: 0.92

Sample: Garments (2573), Footwear (210), Overall (2829)

Overall:

- Garments: 0.883
- Footwear: 0.885
- Overall: 0.882

Appendix 7: Detailed avoided impact calculations

Overall calculation

Net avoided impact for Otrium

The net avoided impact for Otrium is calculated as an aggregate of impacts calculated for each brand. There are ~500 brand partners who sell their items through the Otrium platform. These calculations are performed for each impact category investigated - climate impact, waste generated, water use, and nonrenewable resource use (fossil).

$$I_{net,\ Otrium} = \sum I_{net,\ brand} \quad (1)$$

Net avoided impact per brand

The net avoided impact for each Brand is in turn calculated as an aggregate of all its sales. For example, brand 'A' sells 10 T-shirts and 5 trousers. The net avoided emissions of brand 'A' is therefore the aggregated net avoided impacts from 10 T-shirts and 5 trousers.

$$I_{net,\ brand} = \sum I_{net,\ product} \quad (2)$$

Net avoided impact per product

The net avoided impacts per product ($I_{net,\ product}$) are calculated as follows for each item:

$$I_{net,\ product} = \sum I_{net,\ path} \times D_{path} \quad (3)$$

Where,

- $I_{net,\ path}$ is the net carbon emissions and waste of off-price for each product per pathway. This takes into account the impact generated by the 'status quo' off-price pathway, the carbon and waste avoided by new purchases where the item is 'deadstock', and carbon and waste generated by additional market effects such as overconsumption.
- D_{path} is the estimated change in each alternative pathway due to absence of off-price, calculated based on survey responses from fashion brands. The change in the clothing flows to each alternative pathway are not differentiated as a function of the item type. E.g. T-shirt and jackets are assumed to follow the same alternative pathway in the absence of off-price, as per the survey responses.

$I_{net,\ path}$ for each pathway, per item is calculated using equation (4) below. The first term in the above equation captures the emissions of off-price (Otrium) in the status quo scenario whereas the last two terms relate to the estimated emissions of diverting to an alternative pathway in the no Otrium scenario.

$$I_{net,\ path} = I_{offprice} - I_{new} * y - I_{alt.\ path} \quad (4)$$

Where,

- $I_{offprice}$ is the carbon emissions and waste of an item sold through the off-price pathway. This includes all life cycle stages of a product, plus the impacts generated by Otrium's own operations (e.g. offices and warehouses) calculated using data supplied by Otrium.
- I_{new} is the carbon emissions and waste of a similar new item sold. This takes into consideration the system wide change in

demand in the no Otrium scenario. This includes all life cycle stages of a new item.

- *y* signifies the displacement of new clothing items happening due to purchases through Otrium, which takes into account the potential increase in additional new purchases due to several factors, such as, price discounting, access to better brands, or overall better purchase deals. This was estimated by means of a consumer survey as described in section X. Meanwhile, the complement of is interpreted as the additional purchase rate estimate.
- $I_{alt.\ path}$ is the carbon emissions and waste of an item following an alternative pathway. For example, items produced, warehoused, and then sent for disposal via recycling.

$I_{offprice}$ can be disaggregated as:

$$I_{offprice} = I_{manf.} + I_{dist.} + I_{dist,\ offprice} + I_{use} + I_{EOL} \quad (5)$$

Where,

- $I_{manf.}$ is the impact of manufacturing a new item, from raw material extraction until product assembly
- $I_{dist.}$ is the impact during the distribution and warehousing of a new item
- $I_{dist,\ offprice}$ is impact during distribution and warehousing due to off-price
- I_{use} is the impact of the usage of the item
- I_{EOL} is the carbon emissions and waste at the end-of-life

$$I_{new} = I_{manf.} + I_{dist.} + I_{use} + I_{EOL} \quad (6)$$

Extra note on warehousing:

Based on survey responses from brands (N=17), items that are not sold are held in the warehouse for an average of 18 months before being disposed of through different methods. For both scenarios (‘Status quo, Otrium’ and ‘alternative, no Otrium’), the average warehousing time per item is therefore assumed to be 18 months, plus any additional warehousing time related to the different pathways listed below.

1. Holding in inventory

Assumptions: The product is held in inventory for 6 months on average (min 1-max 12 months) and eventually resold, leading to no avoided purchase of new clothing and therefore no avoided impact from the pathway itself. However, additional impacts are generated by the additional warehousing, which is otherwise avoided by sale through Otrium.

Sources: Impacts of warehousing were calculated using Fichtinger et. al. 2015 and Bottani et. al. 2019. The inventory holding duration was calculated as a distribution between 1-12 months.

Calculation:

Equation (4) for this scenario becomes:

$$I_{net,\ warehouse} = I_{offprice} - I_{new} * y - I_{warehouse}$$

$$I_{net,\ warehouse} = (I_{manf.} + I_{dist.} + I_{dist,\ offprice} + I_{use} + I_{EOL}) - (I_{manf.} + I_{dist.} + I_{a\text{-}warehouse} + I_{use} + I_{EOL}) - I_{new} * y$$

$$I_{net,\ a\text{-}warehouse} = I_{dist,\ offprice} - I_{a\text{-}warehouse} - I_{new} * y$$

Where $I_{a\text{-}warehouse}$ is the impact from additional warehousing.

2. Upcycling

Assumptions: Upcycling processes include cutting and sewing and overdyeing. For footwear, upcycling involves stitching and replacing elements like shoelaces. Colouring is assumed for footwear 33% of the time. The product is eventually resold, leading to no avoided purchase of new clothing and, therefore, no avoided carbon emissions and waste from the diversion to this pathway. However, negligible carbon and waste is generated by the upcycling process, which is otherwise avoided by sale through Otrium.

Sources: Based on the typical upcycling process from fashion experts expected. 33% chance is assumed for each cut and sew, dyeing or bleaching happening. All three can also happen in one case. As such, all are entered as probabilities. Bleaching and dyeing scale with the garment weight but the cut and sew does not. For cut and sew, light repairs are assumed, so data from T-shirt assembly is used (Sandin et al., 2019; Cotton Inc., 2017; Zhang et al., 2015). For bleaching and dyeing, an average of cotton and polyester processes are used (Sandin et al. 2019, BAT 2019, Cotton Inc. 2017).

Calculation:

$$I_{net,\ upcycle} = I_{dist,\ offprice} - I_{new} * y - I_{upcycle}$$

$$I_{net,\ upcycle} = (I_{manf.} + I_{dist.} + I_{dist,\ offprice} + I_{use} + I_{EOL}) - (I_{manf.} + I_{dist.} + I_{a\text{-}upcycl}e + I_{use} + I_{EOL}) - I_{new} * y$$

$$I_{net,\ upcycle} = I_{dist,\ offprice} - I_{a\text{-}upcycle} - I_{new} * y$$

Where $I_{a\text{-}upcycle}$ is the impact from upcycling.

3. Selling to other 'stock buyers'

Assumptions: The product is eventually resold, leading to no avoided purchase of new clothing and, therefore, no avoided impact from diversion. Additional carbon and waste is generated by the transportation from the point of collection to the point of sale, which is otherwise avoided by sale through Otrium. This is assumed to be between 300-1150 km (the same as for sale via charities), following a conservative approach to avoid overestimation of avoided emissions. Inbound secondary packaging is taken into account for sale through stock buyers as well.

Sources: Based on anecdotal evidence from industry professionals. Transportation distance is based on the distance travelled by a clothing item for local reuse (Trzepacz et al., 2022 and Schmidt et al., 2016).

Calculation:

$$I_{net,\ stock\text{-}buyers} = I_{dist,\ offprice} - I_{new} * y - I_{stock\text{-}buyers}$$

$$I_{net,\ stock\text{-}buyers} = (I_{manf.} + I_{dist.} + I_{dist,\ offprice} + I_{use} + I_{EOL}) - (I_{manf.} + I_{dist.} + I_{a\text{-}stock\text{-}buyers} + I_{use} + I_{EOL}) - I_{new} * y$$

$$I_{net,\ stock\text{-}buyers} = I_{dist,\ offprice} - I_{a\text{-}stock\text{-}buyers} - I_{new} * y$$

Where $I_{a\text{-}stock\text{-}buyers}$ is the impact from the transportation of the item to stock buyers.

4. Selling to employees

Assumptions: The product is eventually resold/ gifted, leading to no avoided purchase of new clothing and no avoided carbon emissions from diversion. No impact is generated by sales to employees, which typically take place in the office without transportation to another sale location.

Sources: Based on anecdotal evidence from Otrium and other industry professionals.

Calculation:

$$I_{net,\ employee} = I_{dist,\ offprice} - I_{new} * y - I_{employee}$$

$$I_{net,\ employee} = (I_{manf.} + I_{dist.} + I_{dist,\ offprice} + I_{use} + I_{EOL}) - (I_{manf.} + I_{dist.} + I_{a\text{-}employee} + I_{use} + I_{EOL}) - I_{new} * y$$

$$I_{net,\ employee} = I_{dist,\ offprice} - I_{new} * y$$

Where $I_{a\text{-}employee}$ is the impact from sales to employees (= zero).

5. Donating to charities

Assumptions: Products donated to charities by fashion brands are considered to be 'deadstock' since they have zero economic value. Of all donated items to charities, ~10-30% is typically sorted as 'A-Grade' and resold in local charity shops, thrift or vintage stores, which is the most likely case for excess stock items. As such, local sale is assumed for donated items. For context, the items not sorted as 'A-Grade' are sold to textile merchants or recyclers. Out of these, the majority of items (~45-60%) are exported abroad, where a substantial proportion is disposed of without being used. Of the remaining donations which aren't exported, ~5-10% ends up as waste and ~25-50% is downcycled into wipes or insulation fillers. Donation to charities results in partial avoided purchase (or replacement) of a new item, and associated **partial** avoided impacts. The proportion of avoided impacts is informed by the difference between two Replacement Rates: via charities (*r*) and via Otrium (*y*). Additional carbon and waste is also generated by the transportation from the point of collection to the point of sale (assumed to be between 300-1150 km), which is otherwise avoided by sale via Otrium.

Sources: Clothing flows from charities operating in Western Europe are described in Trzepacz et al., 2022 and Cobing et al., 2022. Transportation distance is based on the distance travelled by a clothing item for local reuse (Trzepacz et al., 2022 and Schmidt et al., 2016). The Replacement Rate (~33%) for sales through charity or vintage stores was obtained for European geographies (Farrant et al. 2010 recalculated in Norup et al. 2019; Stevenson et al. 2013). More sources were found corroborating the above process flows (source 1, source 2, source 3, CBI report)

Calculation:

$$I_{net,\ charities} = I_{offprice} - I_{new} * y - I_{charities}$$

$$I_{net,\ charities} = (I_{manf.} + I_{dist.} + I_{dist,\ offprice} + I_{use} + I_{EOL}) - (I_{manf.} + I_{dist.} + I_{c\text{-}trans} - I_{new} * r + I_{EOL}) - I_{new} * y$$

$$I_{net,\ charities} = I_{dist,\ offprice} + I_{use} - I_{c\text{-}trans} + I_{new} * r - I_{new} * y$$

$$I_{net,\ charities} = I_{dist,\ offprice} + I_{use} - (I_{c\text{-}trans} - I_{new} * r) - I_{new} * y$$

Where,

r is the Replacement Rate for sales through charities or vintage stores;

$I_{c\text{-}trans.}$ is the impact of additional transport in the charities pathway; and

6. Disposing via landfill or incineration

Assumptions: The product is directly disposed of via landfill or incineration without being used by consumers, resulting in an unfulfilled consumer demand. This leads to the production, distribution and sale of a new clothing item (and associated carbon emissions and waste), which is otherwise avoided by sale via Otrium. However, this benefit may be partly 'offset' by an increase in purchases of new items driven by

discounting (*y*), as outlined in Part 3. Disposal via landfill or incineration only results in a **partial** avoided purchase of a new item.

Sources: End-of-life models take into account the transportation and breakdown of clothes landfilled or incinerated at the end of their use as per Kohler et al, 2021. Landfill and incineration models are adjusted according to the expected split of fossil:biogenic content in textile waste as per ratio between synthetic and natural/animal based fibres in global fibre production.

Calculation:

$$I_{net,\ disp.} = I_{offprice} - I_{new} * y - I_{disp.}$$

$$I_{net,\ disp.} = (I_{manf.} + I_{dist.} + I_{dist,\ offprice} + I_{use} + I_{EOL}) - (I_{manf.} + I_{dist.} + I_{use} + I_{EOL}) - I_{new} * y$$

$$I_{net,\ disp.} = I_{dist,\ offprice} - I_{new} * y$$

7. Disposing via recycling

Assumptions: The product is directly disposed of via recycling without being used by consumers, resulting in an unfulfilled consumer demand. This leads to the production, distribution and sale of a new clothing item (and associated carbon emissions and waste), which is otherwise avoided by sale via Otrium. However, this benefit may be partly 'offset' by an increase in purchases of new items driven by discounting (*y*), as explained in Part 3. Disposal via recycling only results in a **partial** avoided purchase of a new item. Garments are typically recycled into rags for insulation, cotton wipes or fibres. The carbon and waste generated or credited from the recycling process and resulting substituted virgin products is also accounted for.

Sources: Recycling distances input as a distribution from multiple sources (PEFCR30, Trzepacz et al., 2022; Schmidt et al., 2016 and Bianco et al., 2022). Split of recycling processes of textiles into fibre, wipes and rags estimated from various sources (PEFCR30, Refashion 2021, Fashion for Good 2022). Recycling impacts for textile to fibre recycling modelled using Duhoux et al. 2022, Zamani et al. 2011, Moazemma et al. 2022, Bianco et al. 2022 and Schmidt et al. 2016. Recycling impacts for textile to wipes or rags recycling modelled using Schmidt et al. 2016. Recycling processes are assumed to have an efficiency between 80-90%. Recycled fibres avoid an average of polyester fibres and cotton lint since these two are the most common fibres in the market (internal database). Recycled wipes avoid an average of tissue and cotton greige fabric. Recycled rags avoid the production of stone wool and vermiculite insulation.

Calculation:

From Equation (3), avoided emissions and waste per product for recycling pathway = $I_{net,\ recycle} \times D_{recycle}$

$I_{net,\ recycle} \times D_{recycle}$ can be disaggregated into:

$$D_{recycle}(I_{net,\ recycle\text{-}fibre} \times D_{recycle\text{-}fibre} + I_{net,\ recycle\text{-}wipes} \times D_{recycle\text{-}wipes} + I_{net,\ recycle\text{-}rags} \times D_{recycle\text{-}rags})$$

Where, $D_{recycle\text{-}fibre}$, $D_{recycle\text{-}wipes}$ & $D_{recycle\text{-}rags}$ are the % recycled into fibres, wipes and rags respectively out of the total sent to recyclers. Whereas, $D_{recycle}$ is obtained from survey responses.

Net impact from recycling items into fibres can be calculated as:

$$I_{net,\ recycle\text{-}fibre} = I_{offprice} - I_{new} * y - I_{recycle\text{-}fibre}$$

$I_{net,\ recycle\text{-}fibre}$ is then disaggregated as:

$$I_{manf.} + I_{dist.} + I_{dist,\ offprice} + I_{use} + I_{EOL} - (I_{manf.} + I_{dist.} + I_{fibre\text{-}recycling}) - I_{new} * y$$

$$= I_{dist,\ offprice} + I_{use} + I_{EOL} - I_{fibre\text{-}recycling} - I_{new} * y$$

$I_{fibre\text{-}recycling}$ can be further decomposed using the circular footprint formula (CFF) from PEFCR[37].

Equation (8) becomes:

$$I_{net,\ recycle\text{-}fibre} = (I_{dist,\ offprice} + I_{use} + I_{EOL}) - (I_{fibre\text{-}rec} - I_{fibre\text{-}virgin} * Q_{Sout}/Q_p) - I_{new} * y$$

Where,

- $I_{fibre\text{-}rec}$ is the impact of the fibre recycling process, including collection and transport;
- $I_{fibre\text{-}virgin}$ is the carbon emissions or waste arising from the manufacturing and distribution of virgin material assumed to be substituted by recycled materials and
- Q_{Sout}/Q_p is the ratio of the quality of the outgoing secondary material to the quality of the primary virgin material.

The allocation factor A is neglected from the CFF equation since the scope of the analysis is system level. The factor A allocates the burdens and credits between the supplier and user of recycled materials. Therefore, this would be irrelevant if the scope of the analysis quantifies overall change in the recycling impacts due to changing deadstock flows.

Similarly, the net impact of off-price from recycling items into rags or wipes can be calculated as:

$$I_{net,\ recycle\text{-}wipes} = (I_{dist,\ offprice} + I_{use} + I_{EOL}) - (I_{wipes\text{-}rec} - I_{wipes\text{-}virgin} * Q_{Sout}/Q_p) - I_{new} * y$$

$$I_{net,\ recycle\text{-}rags} = (I_{dist,\ offprice} + I_{use} + I_{EOL}) - (I_{rags\text{-}rec} - I_{rags\text{-}virgin} * Q_{Sout}/Q_p) - I_{new} * y$$

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