BREMER BAUMWOLLBÖRSE · SEIT 1872

FIBER TRACEABILITY - A VEHICLE TO ENSURE SUSTAINABILITY OR INJUSTICE?

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APRIL 2026

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ACRONYMS

A&F	Apparel and Footwear
ADI	Acceptable Daily Intake
BC	Better Cotton
BE	Bregal Energy
boe	Barrel of oil equivalent
c	circa (approximately)
COFRA	Centrale Organisatie Voor Financiering van de Raden van Arbeid (Cofra Holding)
EIP	Environmental Integrity Project
EPA	Environmental Protection Agency (United States)
EU	European Union
FPW	Flowback and produced water
GD	GlobalData
ICAC	International Cotton Advisory Committee
LCA	Life Cycle Assessment
LNG	Liquefied natural gas
MRL	Maximum Residue Limit
NYT	The New York Times
PAN	Pesticide Action Network
PBI	Permanent bale identification

ACRONYMS

PEF	Product Environmental Footprint
PET	Polyethylene terephthalate
PFAS	Per- and polyfluoroalkyl substances
PTA	Purified terephthalic acid
rPET	Recycled polyethylene terephthalate
RoR	Right of Reply
Sb	Antimony
SDGs	Sustainable Development Goals
SE	Stand Earth
TE	Textile Exchange
UN	United Nations
UN/CEFAT	United Nations Centre for Trade Facilitation and Electronic Business
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
USDA	United States Department of Agriculture
WFN	Water Footprint Network

A reviewer who wishes to remain anonymous, Shannon Mercer, Paul Swan, and Meriel Chamberlin were sent the final draft of this paper to review in November 2025. Cascale, Textile Exchange, Better Cotton, Ecobalyse, and Glimpact were all offered a right of reply in March 2026. Cascale and Textile Exchange responded. We thank them all for their respective contributions. Any errors or omissions, however, remain our own.

Please note: This report is restricted to a factual analysis. No recommendations are offered

April 2026.

EXECUTIVE SUMMARY:

(NB. Please see the body of the report for abbreviations and source links.)

This paper examines the traceability requirements and standards applied to two of the most important fibers for the global apparel market - polyester and cotton, which together account for nearly 80% of global fiber production. It was commissioned to evaluate the validity and accuracy of traceability claims—stated and implicit—which have been standard in sustainable textiles and apparel for the past decade.

Those assertions can be condensed into 5 foundational claims:

i) When considering toxicity, water consumption, carbon emissions, and land use, virgin polyester production has a significantly lower environmental impact than virtually all farmed fibers.

ii) Impacts vary little in polyester manufacturing, so a single European LCA is representative of global virgin production (see section 3).

iii) Sourcing risks, arising from inadvertent use of fiber from a proscribed source - Xinjiang, for example - are high for cotton, but not for polyester.

iv) Given i) ii) and iii), to minimize risk/harmful impacts, it is vital to trace farmed fibers, which represent only c26% of the global supply. It is not necessary to trace virgin polyester, although that fiber alone accounts for 59% of the global total.
And finally,

v) It is, in any case, impossible to trace polyester back to the oil or gas feedstock.

As this paper will demonstrate, all five claims are unsubstantiated and seriously misleading. Indeed, as we will argue, this failure to trace and examine polyester production has resulted in a significant underestimation of polyester's environmental impact. This is about to be baked into legislation, and if not corrected, may lead to a calamitous misallocation of resources

Some sample findings:

1 From the extraction of the feedstock (e.g., crude oil or natural gas) to the production of the plastic, the risk of highly hazardous chemicals and the incidence of human mortality in the polyester supply chain have been seriously underestimated. With the rise of shale, tar, and tight oil and gas exploitation and the increasing consumption of plastic fibers, those risks are growing.

a) The use of chemicals in oil and gas production is particularly notable in all forms of fracking. In 2024, US oil and gas output totaled 10.7 billion barrels of oil equivalent (boe), 60% more than that of the second-most important producer, Russia. Almost 65% of US crude oil and almost 80% of US dry natural gas are obtained from shale and tight oil formations. Fracking is also expanding in Canada and China. Developments in Russia and Saudi Arabia are expected/underway (see section 2).

A 2022 compendium of US investigations into risks and harms linked with fracking found that over 200 airborne chemical contaminants have been detected near drilling and fracking operations.
61 are classified as hazardous air pollutants. One study found that the elderly who lived closest to wells had a 2.5% higher mortality risk. Another found that children aged 2-7, living near gas wells, were 2-3 times more likely to be diagnosed with leukemia. The list goes on (see section 2).

b) More than 2500 chemicals are used, present, or released by the world's most common polyester, polyethylene terephthalate, or PET. Only 31 have been evaluated as without hazard. For example, 1,4-dioxane, a byproduct of the manufacture of PET, presents an 'unreasonable risk to human health'. In 2023, one PET production facility in West Virginia, USA, had an average discharge concentration of 46,140 micrograms per liter. The EPA-acceptable limit is 35 micrograms per liter. Leakage is not limited to production; chemicals in plastic continue to leach throughout its life. A material flow study in China found that the largest release of the PET industry's preferred polycondensation catalyst, antimony, occurs in manufacturing. But fibers disposed of in landfill, incineration, mechanical, and chemical recycling all release antimony to some extent. Antimony is a regulated contaminant with a toxicity on par with, or greater than, arsenic. Antimony is just one of the 236 chemicals known to be released by PET. Most of the other 235 are without hazard data, so their risk is unknown and non-zero (see section 2a).

2 The notion that polyester production pollutes/consumes very little water is a long-standing fantasy, and all evidence to the contrary has been ignored.

a) In 2016, a C&A Foundation-funded evaluation by the Water Footprint Network found that, even excluding fracked feedstock from their calculations, polyester fiber had an average water footprint of 71,000 cubic meters per tonne of fiber. This finding was misrepresented by C&A in their annual sustainability report as 71 cubic meters per tonne of fiber.

b) Shale and tight oil exploitation has increased the grey (waste) water associated with polyester production significantly. This grey water is generally so toxic that even when treated, it is only suitable for reuse in fracking. Of the principal nations that frack commercially, only China has a good track record on the use of flowback and produced water (FPW). The most common disposal method is underground injection. As of 2022, US FPW was primarily pumped into more than 187,000 disposal wells across the country, permanently tainting the surrounding aquifers.

3 The apparel industry has, for years, suggested that factory fibers, unlike farmed fibers, are standardized, and claimed that basing estimates on just one LCA of European PET production provides representative data for global polyester fiber in general.

a) Even including Turkey, European polyester production is insignificant; it's only 3% of the global supply. European data is not representative. Further, the base data for manufacturing is from 2009, and the feedstock data is from 2001. From the source country mix to the emissions associated with each country's output, this data grievously underestimates current impacts.

b) Impacts vary substantially depending on where the PET is manufactured and the type of feedstock used. We have already seen that water use will be considerably greater if the feedstock is fracked. Carbon emissions also vary significantly. Focusing, for example, on flaring emissions, we see that in 2001, when Saudi Arabia was the world's largest producer of oil and gas, Saudi flaring emissions per tonne of oil averaged 0.0012 tonnes of carbon dioxide. In 2024, it was 0.012. That is an increase of 10x. The USA is now the world's largest oil and gas producer. US flaring emissions in 2001 averaged 0.016 tonnes CO_2/tonne of oil. In 2024, it was 0.029. That's an increase of 80%. Equally pertinently, US 2024 flaring emissions were more than double their Saudi equivalent. It is misleading to suggest that applying updated emission factors to the old national oil and gas consumption mix resolves this issue. It is not objectively representative and still significantly understates polyester's impact.

4 We estimate that in 2023, around 15% of the world's polyester supply originated from Russian oil, and the share has increased since. Additional polyester is produced from oil produced in Iran and Venezuela. Indeed, leading Indian polyester manufacturer Reliance Industries has reportedly been sourcing 50% of its oil from Russia to supply those brands enjoying 'exclusive partnerships' with the company, including Bottega Veneta, Balenciaga, Hugo Boss, and Adidas. By the same token, the polyester industry in Xinjiang is expanding rapidly, and both polyester staple and fiber are manufactured in the region. We note that virtually all identified Uyghur re-education units have been in industrial complexes, not farms.

5 Even the limited research and analysis that we have been able to undertake for this paper demonstrates unequivocally that sustainable apparel's long-standing shibboleth, that, unlike farmed fibers, "it is impossible to track synthetic materials back to the source of the crude oil used," is baseless. The vast majority of global PET polyester comes from Asia. India represents 10% of the global supply, and China produces 75%. Within China, the 10 largest producers have a total annual capacity that exceeds China's current output. As for feedstock, there are fewer than 1,300 oil refineries in the world. More than 400 are believed to be currently inactive. Furthermore, just 5 countries account for 50% of global oil and gas production. In contrast, there are 10 million cotton farmers in India alone, and cotton is cultivated across multiple different climatic zones, farm sizes, and soil types.

To suggest that you can trace cotton but not virgin polyester flies in the face of the evidence. As does the assumption that farmed fibers need to be traced to mitigate risk and environmental damage, but virgin polyester does not. The contention by some brands and initiatives that they are absolved as they use/plan to use only recycled polyester is equally invalid. Polyester constitutes c59% of the global fiber supply, and of that, only about 12% is recycled, predominantly (98%) from plastic bottles. There is no commercially significant polyester fiber to fiber recycling, so polyester fibers made from recycled PET are effectively unrecyclable, and bottle recycled PET (rPET) is fundamentally, virgin PET at one step removed.

6 Finally, in response to our offer of a right of reply, leading apparel organisations, Cascale and Textile Exchange, respectively, observed that they support neither the simplification of a single score nor the comparison of the impact of fibers from different production systems, particularly synthetic vs. natural systems (see Annexes 1 and 2). A PEF for Apparel and footwear (A&F) is a single score, specifically intended to enable consumers to compare the impact of synthetic vs natural fibers. We can find no record of either organisation publicly speaking out against the use of the French or EU PEFs for textiles and apparel. Indeed, Cascale has served as Coordinator of the EU Technical Secretariat since 2019.

>> We suggest no specific actions to be taken in light of our findings, and we make no recommendations. We leave this to those who promote the need for traceability in farmed fibers, but not in polyester.<<

TRACEABILITY IN THE GLOBAL TEXTILE SECTOR: PURPOSE AND SCOPE

What is traceability, and why do we want it?

Traceability is the ability to know where our products - in this case, clothes - came from. It is formally defined by the United Nations (UN/CEFACT) as: "the ability to trace the history, application or location of an object in a value chain. In this context, it is defined as the ability to identify and trace the history, application, location and distribution of products, parts and materials to ensure the reliability of sustainability claims in the areas of human rights, labour (including health and safety), the environment and anti-corruption; and "the process by which enterprises track materials and products and the conditions in which they were produced through the supply chain." Moreover, **"Sustainability in the context of garment and footwear value chains means that all activities, throughout a product's life cycle, take into account their environmental, health, human rights and socioeconomic impacts."** [our bold] [1] This paper does not discuss the mechanics of traceability, which have been amply covered elsewhere by the UN, [2] Textile Exchange, [3] and others. We aim rather to examine why traceability is called for, whether current practices in apparel and footwear demonstrate manifest biases, and whether these have broader consequences for impact claims.

As consumers, we want traceability to reassure ourselves that what we have purchased did as little harm and as much good in its creation and manufacture as possible. In 2024, one of the authors of this report bought a Pristine sweater in Tokyo. [4] The naturally coloured cotton was bred by Sally Fox. [5] It was grown by Alvarez farms, spun by Taishoboseki, [6] knit by Morishita-san, and designed and sold to her by Pristine. She did not need third-party certification, nor did she need to know how much water, compost, or manure was used to cultivate the cotton. A purported notion of associated carbon emissions, calculated by some Life Cycle Assessment (LCA) tool, was not required. The author is as certain as anyone can be that the cotton was cultivated and the sweater manufactured with the minimum environmental impact and maximum return to farmers, that conditions permitted. This, as determined by the true experts. The people who made it.

In other words, in the context of apparel and footwear, when brands and consumers consciously select who to buy from and why, traceability comes automatically. But when the only metric of importance along the entire supply chain is price, then neither brands nor consumers have any direct relationship with whoever they are buying from, and they may well switch allegiance with every order. As a result, traceability and, in theory, accountability must be somehow tacked onto a product nobody is invested in.

How does the textile and apparel sector achieve traceability? Fashion is dominated by the notion that apparel can become sustainable simply by switching fibers, and that the most important determinant of any shoe or garment's sustainability is whether it was produced from 'preferred' or 'certified' materials. This is not substantiated by the data. The major impacts of apparel production are determined by where and how an item is manufactured. [7] This paper, however, examines only fiber traceability claims.

In 2024, calculations by Maia Research [8] and Textile Exchange show that 75% of global fiber was manmade, dominated by plastics (69%), primarily polyester (59%). Only 25% of global fiber was 'natural', and most of that (19% of the global total in 2024) was cotton. [9]
Given that together, polyester and cotton represented almost 80% of the global total in 2024, we simplify what is an extensive topic by limiting our discussion to traceability in these 2 fibers.

1. https://unece.org/sites/default/files/2022-01/ECE-TRADE-463E.pdf
2. https://www.bsr.org/reports/BSR_UNGC_Guide_to_Traceability.pdf
3. https://www.fashionforgood.com/case-study/textile-tracer-assessment/
4. https://pristine.jp/
5. https://www.vreseis.com/
6. https://www.taishoboseki.co.jp/
7. https://gcbhr.org/backoffice/resources/amplifying-misinformation.pdf
8. https://www.maiaresearch.com/About/index.html
9. https://2d73cea0.delivery.rocketcdn.me/app/uploads/2025/09/Materials-Market-Report-2025.pdf

1. IMPLEMENTATION OF TRACEABILITY IN POLYESTER AND COTTON SUPPLY CHAINS

We cite the leading preferred or sustainable fiber initiative: Textile Exchange (TE). Textile Exchange is well aware of the preponderance of polyester in its members' fiber sourcing. The TE 2023 Material Change Insights report shows that polyester represented 30% of reporting brands' fiber portfolio. Of this, 35% was described as 'recycled'. This is a misnomer because it is not polyester fiber that has been recycled. It's bottles. (1) Despite the significant role played by polyester in reporting members' fiber mix; despite knowing that the largest non-participating member brands, including Shein, have much higher use of polyester (in Shein's case, it's 82%); despite acknowledging that polyester constitutes 59% of the global fiber supply (of which 88% is virgin fossil polyester), TE documents no virgin polyester traceability schemes and has no "preferred" virgin polyester. (2)

In contrast, TE states that virgin mohair constitutes 0.004% of the global fiber supply, and alpaca, 0.005%. Yet TE's 2025 Materials Market Report lists 1 standard each (TE's own). Virgin cashmere is said to account for 0.02%, but TE lists 4 cashmere programs. As for virgin cotton, which is 19% of the global fiber supply, less than half the relative contribution of polyester, TE lists 19 cotton schemes. (3)

TE's justification is that it is **impossible to trace** polyester back to the original feedstock. We quote the aforementioned 2023 report: "Country of origin for polyester refers to polymer production, collection of recycled feedstock, and country of feedstock production for biobased polyester. **Since it is impossible to track conventional virgin polyester back to the original oil** well (the equivalence of the cotton farm or sheep farm) defining exactly the "country of origin" for virgin polyester is challenging." (4)

TE continues to maintain this position. This is from TE's Materials Benchmark 2024:
"Since tracking synthetic materials back to the source of the crude oil used is impossible, brands were asked to report the country of origin of the polymer production or the country where the recycled feedstock was collected." (5) In their RoR (see Annex 2), TE contends, and we quote:" This statement has been taken out of necessary context, as it was published in relation to connecting the specific source of the oil through to the specific product in which that material is used. Systems to track the provenance and production practices in the oil and gas supply chain to textile and apparel products do not exist at scale today."
But that is precisely the point of this report. The systems do not exist for polyester. Should they, and could they?

In 2023, India alone had 10.3 million cotton farmers, (6) most of whom were smallholders, many with only rudimentary schooling. The exact number and name of global Polyethylene Terephthalate producers, on the other hand, is known, and readily available (for a price), (7) as is an abundance of other data. In preparing this report, the source we found most frequently cited is GlobalData (GD). GD offers, and we quote: "Comprehensive coverage of upstream assets, including more than 30,000 oil and gas fields and over 100,000 exploration blocks, with ongoing updates. Detailed analysis of the midstream Oil & Gas value-chain, including tracking of 600+ LNG terminals, 3,000+ gas processing plants, 5,000+ storage terminals, and 7,000+ pipelines. Comprehensive analysis of downstream assets, covering 1,200+ refineries and 10,000+ petrochemical plants. One-stop shop for information on ongoing projects, with details on around 4,000+ across the value chain. Analysis on over 40,000 contracts, with more than 4,000 new contracts added each year." (8)

(1) https://textileexchange.org/news/textile-exchanges-material-change-insights-report-highlights-the-need-for-systems-change-to-support-more-sustainable-materials-sourcing/ (p.47)
(2) https://textileexchange.org/knowledge-center/reports/materials-market-report-2025/
(3) https://textileexchange.org/knowledge-center/reports/materials-market-report-2025/
(4) https://textileexchange.org/news/textile-exchanges-material-change-insights-report-highlights-the-need-for-systems-change-to-support-more-sustainable-materials-sourcing/ (p.49)
(5) https://textileexchange.org/knowledge-center/reports/materials-benchmark-insights-and-trends-2024/
(6) https://baumwollboerse.de/en/competencies/publications/report-on-un/
(7) https://www.globaldata.com/store/report/polyethylene-terephthalate-market-analysis/
(8) https://www.globaldata.com/industries-we-cover/oil-gas/?_gl=1*gfc39v*_ga*MzIxMjYwMDkyLjE3NTM1MTMwMDY.*_ga_TDKVNS5N2K*czE3NTUx NjExMjAkbzkkZzEkdDE3NTUxNjE2Mzgka-jMxJGwwJGgw#

Indeed, we provide links to the names of 728 of the world's c825 active refineries in this report. Surprisingly, the contention that virgin polyester is impossible to track does not appear to have been investigated by anyone. Brands, the European Union (EU), United Nations (UN) agencies, and sustainability journalists have simply accepted this assertion at face value.

A few examples:

"Why Leaving a Trace Is Becoming Important to Fashion," published by Sourcing Journal in September 2024, does not mention the word polyester once. It mentions cotton 20 times and takes it for granted that brands need to trace their cotton, but not their virgin polyester. (1)

"Innovation, Transparency and Traceability: A Must in the Clothing Industry." UNECE 2023 (2)
The United Nations Economic Commission for Europe (UNECE) was set up in 1947 by ECOSOC. It is one of five regional commissions of the UN. (3)

"Recommendation No. 46: Enhancing traceability and transparency of sustainable value chains in the garment and footwear sector" was published by UNECE and the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) in 2022. (4) This "sustainability pledge" mentions cotton and how to trace it 36 times. Polyethylene Terephthalate (PET), or polyester, and how to trace the most important fiber in the apparel supply chain, is not mentioned once.

Textile Exchange member Shein has this to say: "Material Traceability: Accurately tracing our operations' impacts on biodiversity and animal welfare requires identifying and understanding the sources of our materials.
SHEIN has partnered with TÜV Rheinland to develop our proprietary Traceability Management System, aimed at tracing material quality and verifying sustainable material sources along our supply chain."
But Shein admits that for 2024, 81.5% of its fiber portfolio was polyester. Cotton represented 6.7%, viscose 4.6%, and wool, linen, and all the rest didn't even account for 1%. In other words, the fibers that Shein trumpets tracing with its "proprietary Traceability Management System," constitute less than 12% by weight of the fibers the company designates for use by its contract manufacturers. With the possible exception of the (7%) recycled element, the 82% represented by polyester, Shein does not trace. (5)

Similarly, Brenninkmeyer family-owned C&A (on which, more later) states: "We are committed to a high level of transparency and traceability in our supply chain." (6) But nowhere in the 2023 or 2024 C&A sustainability reports is there any mention of tracing virgin polyester. For 2024, C&A contends that polyester constitutes only 25% of its fiber mix. However, this may not include linings and trims, and if so, it is an underestimate. (7) H&M claims to use 22% polyester, but "This includes commercial products, shell fabric materials, hence does not include materials used as filling, lining or trims on garments." So it is definitely an underestimate. (8)

Much hyped sustainability advocate Patagonia produced its first impact report in 2025. (9) Of the brands discussed here, Patagonia comes second only to Shein for the percentage of polyester in their fiber mix. Almost 60% of the company's total material by manufactured weight is polyester, and a further 14%+ is nylon. In other words, three-quarters of Patagonia's offering is fossil-based.

Patagonia, along with others like H&M and Ikea, claim to use entirely, or almost entirely, recycled polyester. But currently, as Patagonia itself admits, virtually all recycled polyester fiber and fabric is derived from recycled plastic bottles. (10) Demand for plastic bottles is not falling, so every plastic bottle withdrawn from the bottle system will have to be replaced by a new virgin bottle (Indeed, the beverage industry has filed several complaints with the European Commission on precisely these grounds). (11)
It follows automatically that globally, these substitutions generate no necessary net savings in virgin PET production.

(1) https://www.globaldata.com/store/report/polyethylene-terephthalate-market-analysis/
(2) https://unece.org/circular-economy/news/innovation-transparency-and-traceability-must-clothing-industry
(3) https://unece.org/mission
(4) https://thesustainabilitypledge.org/toolbox/2200030_E_ECE_TRADE_466_WEB.pdf
(5) https://www.sheingroup.com/our-impact/planet/sourcing-responsible-products-and-materials/
(6) https://www.c-and-a.com/eu/en/corporate/company/sustainability
(7) https://www.c-and-a.com/eu/en/corporate/company/sustainability/reporting
(8) https://hmgroup.com/investors/annual-and-sustainability-report/
(9) https://eu.patagonia.com/gb/en/progress-report/
(10) https://eu.patagonia.com/gb/en/progress-report/
(11) https://www.euractiv.com/section/eet/news/eu-commission-rejects-priority-industry-access-to-recycled-pet-bottles/

In other words, virtually all fiber PET is currently virgin PET. Either directly, because the PET was produced to manufacture polyester filament or staple. Or, at one step removed, because PET will have been produced to manufacture a bottle to replace the one that has been converted into fiber. Furthermore, PET bottles that have been recycled can be recycled again, multiple times. Their diversion into fiber breaks that virtuous circle.

Under the circumstances, it is not unreasonable to suggest that Patagonia, C&A, H&M, IKEA, and others cannot absolve themselves of any responsibility for the production of virgin PET and so of any need to ensure traceability in the virgin supply chain, because they only use recycled bottle PET. In their RoR, TE states that its "goal for the industry to move away from use of virgin fossil-based feedstocks as rapidly as possible". Quite, but at present their recycled standard covers bottle rPET.

And is it even true? Is it impossible to track conventional virgin polyester back to the original oil (or gas) well, as TE contends and major brands and initiatives claim to believe? This report evaluates that question first. We then examine whether, if everyone contends that traceability is needed for cotton production, it is also vital for polyester and PET production.

A quick aside in this context, panels and papers on the need for traceability almost invariably invoke Xinjiang cotton. But virtually all identified Uyghur re-education units have been in industrial complexes, not farms, and Xinjiang produces polyester (and viscose for that matter), (1) including for export. (2)

A) FEASIBILITY OF TRACEABILITY IN POLYESTER SUPPLY CHAINS

This is the 21st Century. Of course it's possible to track conventional virgin polyester back to the oil (or gas) feedstock. The findings that we have been able to document in a matter of days for this paper aside, here's the proof. Stand Earth (SE) has an annual revenue of around US$14 million. (3)

In 2023, Textile Exchange's annual revenue was ≈US$24 million. And Stand Earth does not just focus on textiles. Yet in March 2025, Stand Earth released an interactive tool (See Appendix 3). (4) This traced the connections between 5 fracking companies in Texas's Permian Basin — Occidental Petroleum, Devon Energy, Diamondback Energy, and Chevron — through Enterprise Products Partners (5) to more than 25 major consumer brands, including Coca-Cola, PepsiCo, and Nestlé.

While the SE Fracked Plastics Map focuses on packaging, there is no reason why focusing on PET for fiber should be any more complicated. Indeed, two of the intermediary brands listed—Reliance Industries and Indorama—are major producers of PET and polyester.

In the context of cotton, sustainable apparel likes to refer to data protected by paywalls as 'silenced data', suggesting that, because you have to pay to acquire it, this data is being deliberately hidden. Or, as Forbes catchily put it in 2021: "'Silenced Data' Means We Don't Know Global Impacts Of Cotton Pesticides" (6)

In reality, a plethora of cotton data exists that does not require payment (e.g., United States Department of Agriculture (USDA) National Agricultural Statistical Service and ICAC's cotton databook, (7) and, as discussed in the following section, for 31% of the world's cotton, even more detailed information is automatically provided with every bale.

(1) https://www.zthx.com/en/about/introduce.html,
(2) https://www.trademo.com/companies/xinjiang-yuxin-new-materials-co-ltd/47843781
(3) https://stand.earth/wp-content/uploads/2024/12/Final-Signed-Financial-Statements-1.pdf
(4) https://stand.earth/resources/fracked-plastics/
(5) https://www.enterpriseproducts.com/operations/petrochemical-refined-products/
(6) https://www.forbes.com/sites/brookerobertsislam/2021/12/06/silenced-data-means-we-dont-know-global-impacts-of-cotton-pesticides/
(7) https://quickstats.nass.usda.gov/ and https://icacdatabook.de.r.appspot.com/

As we will note at various points in this paper, detailed information on polyester production, refineries, and oil and gas fields is all available, at a price. We are not suggesting this means that the petrochemical industry is 'silencing' the data to prevent us from knowing the global impacts of polyester. We understand that data costs money to collect, analyse, and collate. If we want it, we have to pay for it. The two leading initiatives monitoring preferred fibers have a combined annual income of USD 64 million from covering less than 30% of global fiber production. Given that polyester is rapidly approaching double that (59% of the total in 2024), the funds needed for certification of preferred polyester would not be prohibitive. (1) Indeed, if integrated into a polyester certification scheme, the data collection will pay for itself.

TE describes itself thus:
"By providing access to the best available data and information, we're fostering joined-up thinking across the **entire supply system.... Through our materials sustainability standards and traceability tools, we're enabling more transparent claims and enhanced industry integrity.**" Textile Exchange 2023 (2)

It is time that TE lived up to its own words.

There is no reason why TE, or anyone else, could not and should not trace virgin polyester. Switching to bottle rPET means brands are still using virgin feedstock, just at one step removed. If TE or its supporting brands are serious about promoting more sustainable fibers, one would expect them to trace virgin PET and accurately account for its impacts. That they don't is presumably a reflection of nothing more than the fact that the sector's many sustainability experts have never asked for this. Why not?

B) FEASIBILITY OF TRACEABILITY IN COTTON SUPPLY CHAINS

As we can see from Table 1, combined, the USA, Brazil, and Australia currently represent 31% of the global cotton supply.

Table 1: Top Producing Countries 2025/2026 Cotton Production

Top Producing Countries

Market	% of Global Production	Total Production (2025/2026, 480 lb. Bales)
China	29%	35 Million
India	20%	23.5 Million
Brazil	16%	18.75 Million
United States	12%	13.92 Million
Pakistan	4%	5 Million
Australia	4%	4.5 Million
Turkey	3%	3 Million
Uzbekistan	2%	2.55 Million
Argentina	1%	1.38 Million
European Union	1.00%	1.2 Million

Table 1: 2025/2026 Total Production 119.86 Million 480 lb. Bales https://www.fas.usda.gov/data/production/2631000

(1) https://baumwollboerse.de/en/competencies/publications/report-on-un/
(2) https://textileexchange.org/knowledge-center/documents/annual-report-2023/

Virtually every bale of cotton produced in the USA, Brazil, Australia, Israel, Greece, and Spain has a permanent bale ID tag (PBI). Each PBI is barcoded with 16 columns, and the format is standardized by the USDA. Everyone follows the format, and all information about the field that the bale came from is available via the barcode.

In one of the wonders of technology, modern farms are now fully integrated systems. Data on water applications, amount, and timing are captured from every sprinkler head in the case of center-pivot systems, and from each pipe in underground systems. Sophisticated cotton implements and harvesters record data on seed application, herbicide, pesticide, and fertilizer applications, which have been captured by systems integrated into the cab of every tractor and each implement towed behind. Harvesters integrate this data with seed cotton yield for every ten-foot square plot of each field. All of this data is available to users of that cotton by simply reading the PBI.

While this degree of sophistication only automatically applies to 31% of the global cotton supply, in 2023/24, cotton from the USA, Brazil, Australia, Israel, Greece, and Spain constituted 3.84 million tonnes or 68% of the Better Cotton (BC) cotton supply.[1] Moreover, while Better Cotton only constitutes ≈ 23% of global cotton production, it represents between 90 and 100% of the sourcing of brands like H&M or IKEA.

This automatically means that data on sustainability's principal preferred cotton, Better Cotton, could be easily traced. As to how many farms we are likely talking about, as we noted in a paper produced last year,[2] in 2022/23, in Brazil, just 366 farms accounted for all 1.32 million hectares of Better Cotton for an average farm size of 3,612 ha/farm. Smaller Brazilian farms are not part of the program. Specifically, there were 3,263 cotton farms in Brazil in 2022/23, meaning that 2,897 were not participating in Better Cotton. Total cotton area in Brazil in 2022/23 was 1.66 million hectares, meaning that there were only 338,000 hectares of cotton in 2022/23 that were not Better Cotton registered. The average size of a farm in Brazil in 2022/23 that did not participate in Better Cotton was just 117 hectares, a ratio of 31:1.[3]

Note, we were unable to update this section with 2023/24 data as the most recent annual Better Cotton report no longer includes data on harvested area by country.[4]

In other words, we are talking about a handful of very large farms. The authors have seen spreadsheets from one such operation, and everything is documented. The different seed types, fertilisers, and pesticides employed, their costs, and yield impacts are all meticulously recorded. To have robust data on almost half of the global supply of Better Cotton, brands need only trace their supply to the bales of ≈400 farms (440 in 2023/24), and precise data on the use of fertilizer, pesticides, and irrigation will automatically follow.

Table 11 in Appendix 3 shows that the large size advantage does not just apply to Brazil. In 2022/23, the average farm size of BC supplier members was 2.8x that of non BC farmers in the same country.

In Australia, we are looking at only 124 farms participating in Better Cotton, whose holdings were on average 7 times larger than those of farms not participating.[5] In the United States, there were only 332 Better Cotton farms that were, on average, twice as large as non-Better Cotton farms.[6]

In 2022/23, in every country for which data are available, except Israel and Mozambique, Better Cotton farms were significantly larger than non-Better Cotton farms. This makes sense because participation in sustainability programs is expensive in terms of both implementing the actions required and time spent recording and verifying data. Larger farms can amortize costs over more hectares, and large farms tend to have monitoring and data collection systems in place to facilitate compliance with program requirements. Larger farms are easier for Better Cotton and any other sustainability initiative to onboard and monitor.

(1) https://bettercotton.org/documents/better-cotton-initiative-2024-25-annual-report/
(2) https://baumwollboerse.de/en/competencies/publications/report-on-un/
(3) https://bettercotton.org/where-is-better-cotton-grown/better-cotton-in-brazil/
(4) https://bettercotton.org/where-is-better-cotton-grown/
(5) https://bettercotton.org/where-is-better-cotton-grown/better-cotton-in-australia/
(6) https://bettercotton.org/where-is-better-cotton-grown/better-cotton-in-us/

If accounting for as much cotton as possible to increase revenue by supplying the needs of the world's largest brands, such as Ikea (1) and H&M, (2) is the objective, as is likely for the management of sustainability programs, then there is going to be an inherent tendency to involve larger farms to secure a reliable supply in sufficient quantity.

As our previous paper in this series, "UN Agencies and the Treatment of Plastic fibers", pointed out, focusing on large farms is a disadvantage if the aim is to prove sustainability from the all-important viewpoint of the SDGs. (3) In terms of measuring environmental impact, however, as we have seen, it is a distinct advantage. Cotton from the largest farms will almost certainly be harvested by one of the modern machines referenced at the beginning of this section.

As we point out in section 2.e), the 2016 Cotton Incorporated LCA, which has been relied upon to indicate global production impacts for conventional cotton for almost a decade, covered 67% of global cotton production. (4) As we have already noted, farms in the USA, Brazil, Australia, Israel, Spain, and Greece provided 68% of Better Cotton in 2023/24. And as we pointed out at the beginning of this section, every bale will come with a PBI providing all the data brands require.

To avoid any misunderstanding, this data is neither specific to nor attributable to Better Cotton. The data would be available regardless of whether the cotton was certified by a program or not. Sustainable apparel claims that we don't know the global impacts of cotton because producers are 'silencing' the data, by which they mean that the cotton industry collects data and then hides it behind paywalls. (5) Perhaps the cotton experts consulted by Forbes were unaware of modern cotton harvester technology, but as we saw at the beginning of this section, large cotton farmers, especially in Australia, Brazil, and the USA, are doing the best they can to provide data on pesticide, water, and fertilizer applications for every bale of cotton they produce to whoever purchases it.

Contrast this with the polyester sector. To say that polyester plants are every bit as automated as modern large cotton farms would be an understatement. They will track the energy, water, and chemicals going into every batch produced. What is preventing every shipment of PET/polyester from coming with something similar to a PBI attached? Alternatively, physical verification and spectrometric identification have long been essential components of pharmaceutical quality control, to ensure the identity, purity, and quality of materials from raw ingredients to finished products. There is no reason why these could not be employed to trace polyester — or cotton, for that matter.

2. ENVIRONMENTAL IMPACTS OF FIBER PRODUCTION

A) CHEMICALS IN POLYESTER PRODUCTION

In light of what is now known about the transport of micro- and nanoplastics into living organisms and the possible release of these chemicals into the body, the textile and apparel sector has been slow to recognise and acknowledge the toxicity of plastics and their potential impact on humanity and the environment. (6) This has not been the case for the world at large. Indeed, the President of the UN General Assembly included the issue of plastic pollution as a priority during the 73rd Session, 7 years ago. (7)

(1) https://www.ikea.com/gb/en/this-is-ikea/sustainable-everyday/sustainable-materials/100-committed-to-more-sustainable-cotton-pub8ba057d0/
(2) https://hmgroup.com/sustainability/circularity-and-climate/materials/
(3) https://baumwollboerse.de/en/competencies/publications/report-on-un/
(4) https://resource.cottoninc.com/LCA/2016-LCA-Full-Report-Update.pdf
(5) https://www.forbes.com/sites/brookerobertsislam/2021/12/06/silenced-data-means-we-dont-know-global-impacts-of-cotton-pesticides/
(6) https://baumwollboerse.de/en/our-topics/sustainability/danger-warning-about-microplastics/
(7) https://www.un.org/pga/73/plastics/

The United Nations Environment Assembly of the UNEP adopted a resolution in 2022 calling for the development of an international, legally binding instrument on plastic pollution based on a comprehensive approach addressing the full life cycle of plastics. (1)

In May 2023, the United Nations Environment Program (UNEP) published "Chemicals in Plastics: A Technical Report," which 'aims to inform the global community about the often-overlooked chemical-related issues of plastic pollution, particularly their adverse impacts on human health and the environment.' (2) This report was developed in cooperation with the Secretariat of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, and the Stockholm Convention on Persistent Organic Pollutants, with lead authors from the International Panel on Chemical Pollution. (3)

Key findings included:

i) Chemicals are an integral part of plastics;

ii) Chemicals of concern have been found in plastics across a wide range of sectors and product value chains, including textiles;

iii) ten groups are identified as being of major concern due to their high toxicity and potential to migrate impacting our health and our environment;

iv) such chemicals can be released from plastic along its entire life cycle, and women and children are particularly susceptible. (4)

The predominant plastic in textiles and apparel is polyester. PlastChem - State of the science on plastic chemicals was published in April 2025. (5) This study found that focusing on information-rich polymer types resulted in ten polymer types that have information for >550 chemicals each (Figure 1). PET tops the ranking with 2,566 chemicals used, present, or released. Of these, 806 are known to be hazardous, and a further 1,609 chemicals might be hazardous or not (Table 2). Nobody has tested them.

Figure 1: Plastchem — Number of Chemicals and Associated Hazard Information According to Polymer Type

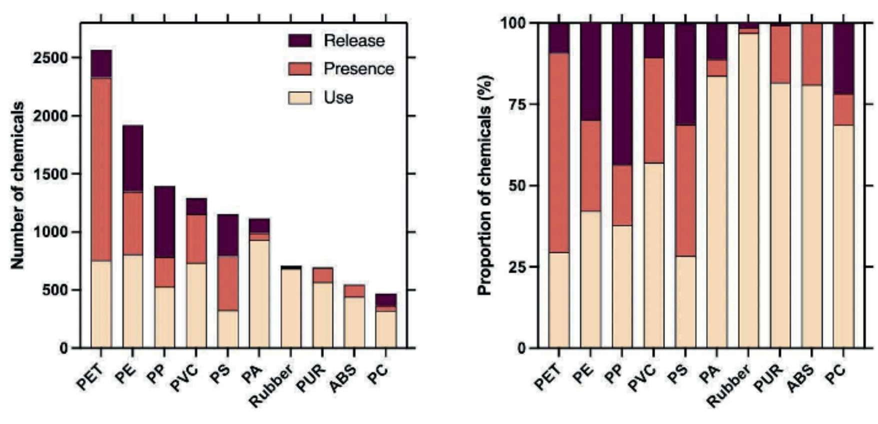

Figure 10: Number of chemicals with evidence for their use, presence, or release from polymer types. *Polymer types with data on <400 chemicals are not shown here. Chemicals that have been analyzed but were not detected, or with inconclusive detection data, are also not shown here.*

Figure 1(1): https://zenodo.org/records/15397723 (P.34)

(1) https://digitallibrary.un.org/record/3999257?ln=en&v=pdf
(2) https://www.unep.org/resources/report/chemicals-plastics-technical-report
(3) https://www.unep.org/resources/report/chemicals-plastics-technical-report
(4) https://www.unep.org/resources/report/chemicals-plastics-technical-report
(5) https://zenodo.org/records/15397723

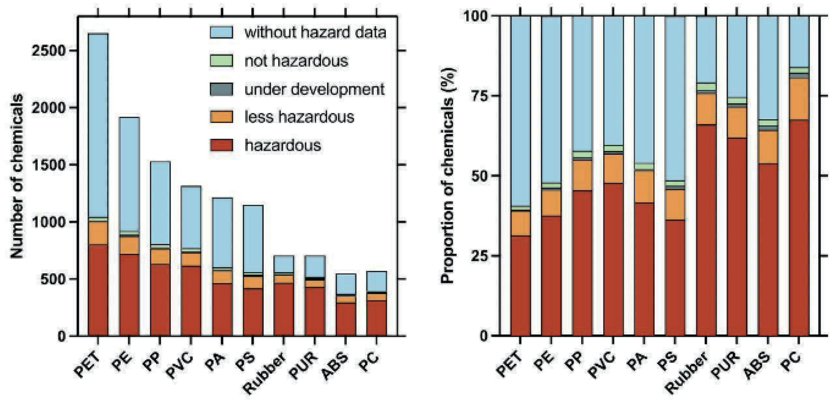

Figure 25: Hazard information for chemicals used or detected in plastics according to polymer type. *The left graph presents the number of chemicals, the right graph shows the proportion of chemicals normalized to the number of chemicals used or detected in each group. Only polymer types with information for more than 550 chemicals were considered here.*

Figure 1(2): https://zenodo.org/records/15397723 (P.60)

Table 2: Plastchem — The Number of Chemicals Used, Present, or Released in PET

Table 10: Overview of the ten polymer types in which most chemicals are used or detected. *Only polymer types with information for >550 chemicals were considered here.*

Polymer	Use	Number of plastic chemicals...					Thereof...		
		analyzed	used	present	released	Sum ᵃ	not hazardous	without hazard data	hazardous
PET	Packaging, food/household, textiles	2914	757 (26%)	1573 (54%)	236 (8%)	2566 (88%)	31 (1%)	1609 (63%)	806 (31%)

Table 2: https://zenodo.org/records/15397723

Building on the Plastchem analysis, a July 2025 article published in Nature points out that 1,322 identified chemicals of concern are **marketed** for use in plastics manufacturing, ie., many chemicals of concern are used knowingly and deliberately. (1) It seems likely that a number could be substituted with less toxic alternatives if the market demanded it. Tracing polyester could encourage this.

Not surprisingly, some of these hazardous chemicals seep into areas surrounding production facilities with automatically harmful effects. It is beyond the scope of this paper to examine all substances and all countries. To illustrate the problem, we focus on 1,4-dioxane in the USA and antimony in China.

In November 2024, the U.S. Environmental Protection Agency (EPA) determined that "1,4-dioxane presents unreasonable risk to human health." (2) In the same month, the Environmental Integrity Project (EIP) released "Plastic's Toxic River." (3) 1,4-dioxane is a byproduct in the manufacture of polyethylene terephthalate (PET) plastic, the feedstock for most polyester. (4)

EIP found that eight plastics plants released an estimated 74,285 pounds of 1,4-dioxane to waterways in 2022. Moreover, the 1,4-dioxane concentrations at the five PET plants that monitor for the pollutant had an average discharge concentration in 2022 and 2023 that far exceeded the EPA acceptable limit (35 micrograms per liter). The highest average concentration in 2023 was at the APG Polytech Apple Grove Facility in West Virginia, which averaged 46,140 micrograms per liter. (5)

(1) https://www.nature.com/articles/s41586-025-09184-8
(2) https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/final-risk-evaluation-14-dioxane
(3) https://environmentalintegrity.org/wp-content/uploads/2024/11/EIP_Report_PlasticsToxicRiver_11.14.24.pdf
(4) https://19january2021snapshot.epa.gov/sites/static/files/2014-03/documents/ffrro_factsheet_contaminant_14-dioxane_january2014_final.pdf
(5) https://environmentalintegrity.org/wp-content/uploads/2024/11/EIP_Report_PlasticsToxicRiver_11.14.24.pdf

The 8 facilities involved belonged to APG Polytech, Alpek, Dow, and Indorama. Mexican-owned Alpek is one of the largest integrated PTA and PET producers worldwide, with an installed capacity of over 8.4 million tons and polyester facilities in the USA, Canada, Mexico, Brazil, Argentina, the UK, Saudi Arabia, and Oman. (1) There is a likelihood that these production facilities might also have the same release of 1,4-dioxane beyond acceptable limits.

As for antimony (Sb) is a regulated contaminant with a toxicity on par with, or even higher than, that of arsenic. (2) Antimony oxide, antimony acetate, and antimony glycoloxide are the preferred polycondensation catalysts (>90% of catalysts) for the synthesis of polyethylene terephthalate (PET), the primary feedstock for polyester. (3)

China has the world's largest Sb reserves. In 2018, Chinese output totalled 89,600 tonnes, 61% of the global supply, and it is estimated that 12.3% of this went into PET production, of which ≈81% was for fibers. Bottle and film production represented only 18%. Moreover, unlike the release of Sb from PET bottles and films, in the manufacture of PET fibers and textiles, high temperature, high pressure, and/or strong alkaline conditions promote the release of Sb from the PET into industrial wastewater. (4) In China, factories for PET fiber and fabric manufacturing are concentrated in Zhejiang and Jiangsu provinces (together, >70% of the domestic production capacity). A 2021 study of 79 factories in the region found that an average of 300.0 mg/kg Sb was added as a catalyst in PET synthesis. However, only ≈207.2 mg/kg Sb was measured in the PET. This suggests that 92.8 mg/kg Sb (approximately 31% of total Sb) was released in the process of PET synthesis. (5)

In Canada, the maximum acceptable concentration for total antimony in drinking water is 6 µg/L. (6) Tests at 33 sites in the Chinese study area found Sb levels in surface water at 19 sites to be over 6 µg/l, and up to as high as >30µg/l. (7) Furthermore, like microfibers, polyester keeps releasing antimony throughout its existence. The material flow analysis in the aforementioned Chinese study found that while the largest Sb release occurred in manufacturing the PET fibers, closely followed by dyeing, fibers disposed of in landfill, incineration, mechanical, and chemical recycling all released Sb to some extent. (8) It is not just antimony that is released in recycling. The aforementioned Nature article notes that "Plastic chemicals may also impede the transition to a circular economy, … and uncontrolled recycling can further perpetuate the spread of hazardous chemicals." (9)

Polyester can be and is manufactured without using antimony as a catalyst. But it's generally more expensive. It can likely also be manufactured without many of the 1,322 known chemicals of concern that are **marketed** for use in plastics manufacturing. If brands and their funded initiatives claim traceability is essential for farmed fibers to allay toxicity concerns, isn't this even more essential in the polyester supply chain?

Moreover, it is not just the toxic chemicals in polymer production that should concern us. As further discussed in the water section of this paper, fracking is an increasingly important source of petrochemical feedstock. The USA is the world's largest oil and gas producer. Almost 65% of 2023 US crude oil (10) and almost 80% of 2023 US dry natural gas (11) was obtained from shale and tight oil formations. Unconventional (fracking, tight oil/gas) extraction generally requires the use of a cocktail of toxic chemicals (as well as polluting portable generators). (12)

A 2011 report by the US House of Representatives found that between 2005 and 2009,14 oil and gas companies used more than 2,500 hydraulic fracturing products containing 750 chemicals and other components. (13)

(1) https://www.alpek.com/who-we-are/#:~:text=As%20one%20of%20the%20leading,of%20over%208.4%20million%20tons
(2) https://pmc.ncbi.nlm.nih.gov/articles/PMC9030621/#%3A~%3Atext%3DThe%20toxicity%20of%20antimony
(3) https://www.sciencedirect.com/science/article/abs/pii/S0048969720381742
(4) https://www.sciencedirect.com/science/article/abs/pii/S0048969720381742
(5) https://www.sciencedirect.com/science/article/abs/pii/S0048969720381742
(6) https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-antimony.html
(7) https://www.sciencedirect.com/science/article/abs/pii/S0048969720381742
(8) https://www.sciencedirect.com/science/article/abs/pii/S0048969720381742
(9) https://www.nature.com/articles/s41586-025-09184-8
(10) https://www.eia.gov/tools/faqs/faq.php?id=847
(11) https://www.eia.gov/tools/faqs/faq.php?id=907&t=8#:~:text=In%202023%2C%20about%2078% 25%20(,production%20was%20from%20shale%20formations.&text=Last%20 updated:%20Sept ember%2019%2C%202024;%20preliminary%20data
(12) https://strathprints.strath.ac.uk/64548/
(13) https://www.damascuscitizensforsustainability.org/wp-content/uploads/2012/03/dems.energy.Hydraulic-Fracturing-Report-4.18.11.pdf

Some of these chemicals, such as benzene and lead, were extremely toxic. Indeed, 29 of the chemicals used were either known or possible human carcinogens or regulated under the Safe Drinking Water Act. Or they were listed as hazardous air pollutants under the Clean Air Act. In addition, fracking companies used proprietary fluids in many instances. In such cases, the companies were injecting fluids containing chemicals that they themselves were unable to identify. (1)

The situation does not appear to have improved. In 2022, Colorado passed a law requiring public disclosure of all chemicals used underground in oil and gas wells, including a ban on PFAS (a group of synthetic chemicals). As of May 2025, the reporting rate was a mere 39%, and almost 65% of the companies concerned had no chemical disclosures appearing on the state's website. Of the 675 wells with no chemical disclosures, 377, or more than half, were operated by Chevron and its subsidiaries, PDC Energy and Noble Energy. (2) As an interesting aside, the Noble Group led the 2012 Inflection Energy funding round that Bregal subscribed to, mentioned in section 2.c). (3)

In light of the above, as well as the rising volume of fracking in the USA (and globally) outlined in section 2.c), it should come as no surprise that in some areas of the USA, contamination of air and water due to fracking operations through chemical infiltration of drinking water during extraction and spills, as well as a consequence of fracking-related air pollutants, poses a serious health hazard. (4)

This is a paper on traceability, not the health hazards of fracking, but we note that epidemiologic studies in the USA have shown a significant correlation between fracking and health outcomes. As of January 1, 2022, 2,239 published peer-reviewed studies on shale and tight gas development were archived in the Repository for Oil and Gas Energy Research database.
Almost 1,000 of those papers had been published since 2018. (5)

As documented in more than 100 studies, over 200 airborne chemical contaminants have been detected near drilling and fracking operations. 61 are classified as hazardous air pollutants with known health risks, including the potent carcinogens benzene and formaldehyde. One study found that the elderly who lived closest to wells had a 2.5% higher mortality risk than those who didn't, and that those who lived downwind had a higher risk of early death than those who lived upwind. Another found that children aged two to seven, living near gas wells, were two to three times more likely to be diagnosed with acute lymphoblastic leukemia (ALL), the most common kind of childhood leukemia, than children who did not live near gas development. (6)

Concerns around health and environmental (as well as seismic) risks have led several countries to ban fracking, including France, Denmark, Ireland, and the UK. Many others have imposed partial moratoriums. Here we note that some countries are eyeing the exploitation of oil sands (bitumen is extracted, using steam, and then upgraded and refined to break down the heavy hydrocarbons into lighter components, which serve as feedstocks for the petrochemical industry). Currently, this is only large-scale in Canada, where toxic tailing ponds in Alberta cover an area greater than 30,000 hectares, and evidence of negative impacts on human and environmental health is accumulating. (7) Yet the apparel sector has expressed no concern whatsoever about the potential hazard associated with this increasingly important source of polyester feedstock and is not attempting to trace polyester to avoid unconventional sourcing.

We contrast this with the sector's focus on glyphosate. This herbicide, also known as Roundup, is currently only banned in Vietnam, and it is authorised for use throughout the EU (with some restrictions), as well as in the USA. (8)

It is claimed that glyphosate causes Non-Hodgkin Lymphoma cancer, and several successful lawsuits have been brought against the producers, Bayer, albeit so far, only in the USA. (9)

(1) https://www.damascuscitizensforsustainability.org/wp-content/uploads/2012/03/dems.energy.Hydraulic-Fracturing-Report-4.18.11.pdf
(2) https://www.psrcolorado.org/oil-gas-chemical-report
(3) https://www.hartenergy.com/news/bregal-energy-increases-investment-inflection-energy-71766
(4) https://e360.yale.edu/features/fracking-gas-chemicals-health-pennsylvania
(5) https://psr.org/wp-content/uploads/2022/04/compendium-8.pdf
(6) https://e360.yale.edu/features/fracking-gas-chemicals-health-pennsylvania
(7) https://www.nytimes.com/2026/03/10/health/canada-oil-sands-fort-chipewyan-alberta.html?unlocked_article_code=1.SFA.uvbr.V-IOZHY5L2fE&smid=url-share
(8) https://phys.org/news/2023-09-glyphosate-restricted.html
(9) https://www.bayer.com/en/managing-the-roundup-litigation

In May 2025, a 'study' published by the Pesticide Action Network (PAN), catchily named "Blood Sweat and Tears", claimed to have found glyphosate in one box of tampons at levels 40 times higher than is permitted in drinking water. (1) Claims made in that publication were rapidly circulated as fact. (2)

Nobody noticed that, unlike the studies we have just referenced showing potential harm in fracking, the PAN study was not published in a peer-reviewed journal. Why not?

We quote experts: "Nearly 500 years ago, Swiss physician and chemist Paracelsus expressed the basic principle of toxicology: "'All things are poison and nothing is without poison; only the dose makes a thing not a poison.' This is often condensed to: "The dose makes the poison." It means that a substance that contains toxic properties can cause harm only if it occurs in a high enough concentration.

In other words, any chemical—even water and oxygen—can be toxic if too much is ingested or absorbed into the body. The toxicity of a specific substance depends on a variety of factors, including how much of the substance a person is exposed to, how they are exposed, and for how long." (3)

This is of crucial relevance to the PAN study because PAN compares the levels of glyphosate found in tampons to permitted levels for drinking water. You don't need to be a scientist to know that people drink large quantities of water, so the permissible level of any potential toxin must be set low. People consume smaller quantities of food, and tampons are not consumed at all.
Exposure is through a far less direct route - absorption through skin or mucosa.

We note similar controversy arose in 2019 over Glyphosate in disposable nappies - an exposure route analogous to that of tampons. The European Commission's response was that: "Glyphosate is approved in the EU and has a MRL of 10 mg/kg for cotton seed." (4) The maximum RL found by the PAN study was far, far lower than that - a mere 0.004 mg/kg. We further note that another highly-hazardous chemical (HHC) in pesticides used on cotton - boric acid - is a common ingredient in vaginal suppositories used to treat yeast and other infections. (5)

Readers will doubtless argue that the same holds for polyester. The fact that toxic chemicals are used in PET production does not automatically mean that PET products are harmful, and the studies we refer to, just like those on Glyphosate, etc, show correlation, not causation.

That is correct.

Let us be clear, we are not suggesting that people are wrong to be concerned about Glyphosate. We are concerned about the use of all potentially harmful chemicals, regardless of type and origin, and we are aware that a 25-year-old landmark paper on the safety of glyphosate was recently retracted. (6)

The argument that we are making here is not that chemicals in plastics are a concern, but that those in cotton are not. We are arguing for science and a level playing field. If apparel brands, legislators, sustainability experts, and the general public are concerned about the chemicals in fiber production, focusing all attention on cotton is misleading and ineffective. We cover chemicals used in cotton cultivation in the next section. Readers will judge for themselves, but we would contend that the threat of toxic chemical impacts lies primarily in plastic fibers, from feedstock extraction to the final product. If brands and their funded initiatives care about toxicity, tracing cotton but not polyester is inconsistent and arguably ineffective.

(1) https://www.pan-uk.org/period-products/
(2) https://www.theguardian.com/environment/2025/may/28/toxic-pesticide-levels-found-in-tampons-40-times-higher-than-legal-limit-for-water
(3) https://www.chemicalsafetyfacts.org/health-and-safety/the-dose-makes-the-poison/
(4) https://www.europarl.europa.eu/RegData/questions/reponses_qe/2019/000816/P8_RE(2019)00 0816_EN.pdf
(5) https://my.clevelandclinic.org/health/drugs/19641-boric-acid-vaginal-suppository
(6) https://www.nytimes.com/2026/01/02/climate/glyphosate-roundup-retracted-study.html?unlocked_article_code=1.S1A.nnje.EEesQpGi52Uf&smid=url-share

B) CHEMICALS IN COTTON CULTIVATION

As we just saw, 2,565 chemicals are used or detected in PET. Of these, 806 are known to be hazardous. By comparison, as shown in Table 3, the number of highly hazardous chemicals used as pesticides in cotton is 135.

Table 3: Highly Hazardous Chemicals Used on Cotton

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Annexure-1 **LIST OF HIGHLY HAZARDOUS PESTICIDES** (Jepson et al., 2020)

	WHO 1a	WHO 1b	GHS Cancer 1A, 1B	GHS Muta 1A, 1B	GHS Repro 1A, 1B	Montreal Protocol	Rotterdam Convention	Stockholm Convention
Acrolein		■						
Alachlor							■	
Aldicarb	■						■	
alpha-BHC/HCH								■
Alpha-chlorohydrin		■						
Aluminum phosphide								
Anthracene oil			■					
Arsenic compounds			■					
Atrazine								
Azafenidin					■			
Azinphos-ethyl		■						
Azinphos-methyl		■					■	
Benomyl				■	■		■	
Beta-cyfluthrin;		■						
beta-HCH/BCH								■
Blasticidin-S		■						
Borax; disodium tetraborate decahydrate					■			
Boric acid					■			
Brodifacoum	■				■			
Bromadiolone	■				■			
Bromethalin	■							
Butoxycarboxim		■						
Cadusafos		■						
Captafol	■		■				■	
Carbendazim				■	■			
Carbetamide					■			
Carbofuran		■					■	
Chlordane							■	■
Chlorethoxyphos	■							
Chlorfenvinphos		■						
Chlormephos	■							
Chlorophacinone	■				■			
Chlorothalonil			■					
Clothianidin								
Coumaphos		■						
Coumatetralyl		■			■			
Creosote			■					
Cyproconazole					■			
DDT							■	■
Demetonne-S-methyl		■						
Dichlorvos; DDVP		■						
Dicrotophos		■						
Difenacoum	■				■			
Difethialone	■				■			
Dinocap					■			
Dinoterb		■			■			
Diphacinone	■							
Disulfotonne	■							
DNOC and its salts		■					■	
Edifenphos		■						
Endosulfan							■	■
Endosulfan I (alpha)							■	■
E-Phosphamidon	■							
Epichlorohydrin			■					
EPN	■							
Epoxiconazole					■			
Ethiofencarb		■						
Ethoprophos; Ethoprop	■							
Ethylene dibromide; 1,2- dibromoethane			■				■	
Ethylene dichloride; 1,2- Dichloroethane			■				■	
Ethylene oxide			■	■			■	
Ethylene thiourea					■			
Famphur		■						
Fenamiphos		■						
Fenchlorazole-ethyl			■					
Fipronil								
Flocoumafen	■				■			
Fluazifop-butyl					■			
Flucythrinate		■						
Flumioxazin					■			
Fluoroacetamide		■					■	
Flusilazole					■			
Formetanate		■						
Furathiocarb		■						
Glufosinate-ammonium					■			
Heptenophos		■						
Hexachlorobenzene	■		■				■	■
HCH/BHC mix isomers							■	
Imidacloprid								
Iprodione			■					
Isoxathion		■						
Lindane							■	■
Linuron					■			
Magnesium phosphide								
Mecarbam		■						
Mercury compounds							■	
Methamidophos		■					■	
Methidathion		■						
Methiocarb		■						
Methomyl		■						
Methyl bromide						■		
Mevinphos	■							
Monocrotophos		■					■	
Nicotine		■						
Nitrobenzene					■			
Omethoate		■						
Oxamyl		■						
Oxydemetonne-methyl		■						
Paraquat dichloride								
Parathion	■						■	
Parathion-methyl	■						■	
PCP; Pentachlorphenol		■					■	
Pentachlorobenzene			■					
Phorate	■							
Phosphamidon	■						■	
Phosphine								
Propetamphos		■						
Propiconazole					■			
Propylene oxide, Oxirane			■	■				
Silafluofen					■			
Sodium fluoroacetate (1080)	■							
Spirodiclofen			■					
Strychnine		■						
Sulfluramid							■	■
Sulfotep	■							
Tebupirimifos	■							
Tefluthrin		■						
Terbufos	■							
Thiamethoxam								
Thiofanox		■						
Thiometonne		■						
Thiram in formulations with benomyl and carbofuran only							■	
Triadimenol					■			
Triazophos		■						
Trichlorfon; metrifonato							■	
Tridemorph					■			
Triflumizole					■			
Vamidothion		■						
Vinclozolin					■			
Warfarin		■			■			
zeta-Cypermethrin		■						
Zinc phosphide		■						
Z-Phosphamidon	■							

Table 3: https://www.icac.org/Content/PublicationsPdf%20Files/d8312b5a_0bd0_47c0_afac_7dcc9ba8fc66/e-cotton-Recorder-2-2024-V2.pdf.pdf

Further, unlike polyester PET, the chemicals in pesticides are applied to the cotton fields during growth. They are not integral to cotton's structure or released during use or disposal. Indeed, the Bremen Cotton Exchange regularly tests for pesticide residues on raw cotton fiber from around the globe. The results are normally published at two-year intervals, but because of COVID, the most recent year of testing was 2020. [1]

The report for 2020 includes results for samples of cotton from 21 countries representing 23 million tonnes of production or 94% of the world total that year. Samples of cotton from 15 countries representing 13.5 million tonnes of production in 2020 had no detectable levels of pesticide residue, while samples from six countries representing 9.5 million tonnes of production (Egypt, Brazil, Greece, India, Kazakhstan, and Spain) exhibited detectable levels of residue from six pesticides.

However, even in the six countries for which samples of cotton exhibited detectable levels of pesticide residue, the levels were less than the Acceptable Daily Intake (ADI), the amount that can be consumed daily over a lifetime without appreciable health risk. For example, samples of Giza 96 (extrafine cotton from Egypt) exhibited 0.08 mg of Profenophos (an insecticide) per kg of cotton lint. The ADI for Profenophos is 0.03 mg/kg of body weight. An adult weighing 70 kilograms would have to eat, not wear but eat, 26 kgs of Giza 96 daily over a lifetime to reach the ADI for this molecule.

The highest levels of pesticide residue were found on samples of cotton from Brazil: 0.05 mg of Acetamiprid (a neonicotinoid insecticide) per kg of cotton, 0.17 mg of 2,4-D (a systemic herbicide) per kg of cotton, and 0.08 mg of Cyhalothrin (an insecticide) per kg of cotton. An adult weighing 70 kilograms would have to eat (not wear) 7 kgs of Brazilian cotton daily for life to reach the ADI for Acetamiprid, 309 kgs of Brazilian cotton daily for life to reach the ADI for 2,4-D, and 4 kgs of Brazilian cotton daily for life to reach the ADI for Cyhalothrin.

Meanwhile, as noted in "The Treatment of Microfibers in Life Cycle Analysis and Product Environmental Footprint Applications - A Brief Primer," [2] more than 2,500 chemicals are used, present, and released by PET. Of those, only 31 are known to be not hazardous, 806 are known to be hazardous, and 1,609 are without hazard data and so could be seriously harmful; we just don't know about them.

We agree that it is important to know what chemicals are present in textile products, how much of each is present, and to know where the chemicals originated. Our point is that, if it is necessary to trace cotton to its origin, not just the country but even the individual farm, then, by the same logic, polyester would also need to be traced, not just to the country of production, but through the value chain of plants and refineries from which polyester is produced, and ultimately to the oil or natural gas that served as the feedstock for the PET molecules.

We do not argue that cotton is a pristine commodity, free of any hazard. Rather, we argue that the hazards represented by cotton are known, well-documented, and monitored, and empirical data from objective sources confirm that the hazards associated with cotton are often exaggerated. In contrast, the chemicals in polyester represent a suite of hazards that are barely catalogued, let alone measured, and those hazards receive little scrutiny because brands and retailers have little incentive to consider such problems.

Since the USA is a major cotton producer, we attempted to find independent, peer-reviewed studies showing that chemicals in US cotton cultivation, just like those in fracking, were associated with increased mortality in the surrounding area. We were unsuccessful.

A proportional mortality study comparing the cotton-growing areas of the San Joaquin Valley with the rest of the State of California did find a statistically significant increase in "respiratory causes" mortality for the period during and immediately following cotton defoliation with DEF and Folex. However, a 1995 paper attempting to replicate the findings of the earlier study determined that the prediction of mortality proportions based on pounds of DEF and Folex used was not statistically significant. On the other hand, an air pollution adjustment factor, total suspended particulates, was a statistically significant independent mortality proportion predictor.

In other words, mortality differentials during defoliation season may have been related to total suspended particulates, not defoliants. [3]

[1] https://baumwollboerse.de/wp-content/uploads/2022/06/Pestizide-1992-2021_nach-Laendern.pdf

[2] https://baumwollboerse.de/wp-content/uploads/2025/01/BWB_Studie_2025_P4.pdf

[3] https://www.jstor.org/stable/44994578

Results from Googling ‘chemicals in cotton’ on 30/07/25 lead with this from the Environmental Justice Foundation: **“Every year, a large number of India’s 5.8 million cotton farmers are poisoned by their exposure to pesticides. Many have died, while many more continue to suffer with chronic illnesses.”** (1) No source is provided for this claim, and in 2023, India had 10.3 million cotton farmers. (2) Number 2 in Google’s ‘chemicals in cotton’ ranking was a June 2022 piece by The Pesticide Action Network. This page on ‘Pesticide concerns in cotton’ states: **“Thousands of cotton farmers and their families suffer from pesticide poisoning every year, and many commit suicide as a result of debt related, at least in part, to high chemical costs.”** (3)

There are indeed a concerning number of farmer suicides in India, and these are documented (albeit possibly underreported) on an Indian government website. In 2018, per 100,000 people, Sikkim had the 6th highest farmer suicide rate in India (and the highest overall suicide rate by a considerable margin). (4) Sikkim produces no cotton whatsoever. The leading cotton-producing state, Gujarat, ranked well below Sikkim for farmer suicides per 100,000 people. Moreover, all Sikkim agriculture has been certified 100% organic since the end of 2015.

We are not saying that something related to organic farming caused the suicides in Sikkim. Nor are we saying that Indian pesticides are not toxic, and there is nothing to worry about. Indian legislators have been attempting to amend the country’s pesticide laws since 2008. But they have faced repeated challenges from the Indian agrochemical industry. However, partial success was finally achieved in 2023, when the Insecticides (Prohibition) Order finally banned four highly hazardous pesticides: Dicofol, Dinocap, Methomyl, and Monocrotophos. (5)

We would further point out that India, in general, uses far fewer pesticides per hectare than the countries pointing the finger. We quote a 2024 peer-reviewed study examining trends in pesticide usage per unit area (kg/ha), (averaged across all crops, not just cotton) in India, Brazil, China, Germany, and the USA:

“Across the examined period, India consistently exhibited lower pesticide usage compared to the other nations. Particularly in Brazil, pesticide usage surged from 1.1 kg/ha in 1990 to 10.9 kg/ha in 2021. Similarly, Germany’s pesticide usage increased from 2.5 to 4.1 kg/ha during the same timeframe. In the USA, it rose from 2.14 to 2.85 kg/ha, and in China, it increased from 1.1 kg/ha to 1.83 kg/ha. Conversely, India’s pesticide usage stood at 0.44 kg/ha in 1990, declining to 0.37 kg/ha by 2021. Notably, in 2008, it plummeted to just 0.09 kg/ha, potentially attributed to the introduction of Bt cotton in 2002 and the subsequent reduction in pesticide use in the pesticide-consuming cotton crop.” (6)

This report also found that, contrary to popular notion, the top Indian states for pesticide use in kg/ha, calculated from the All India Input Survey, 2016–2017, were not major cotton-producing states but Jammu and Kashmir (5.6 kg/ha), Punjab (1.3 kg/ha), and Haryana (1.1 kg/ha). India’s top cotton-producing state in 2024 was Gujarat (0.2 kg/ha). The lowest pesticide application rates were found in the leading cotton states of Madhya Pradesh (<0.1kg/ha) and Rajasthan (0.1kg/ha), respectively. (7)

Of course, this tells us nothing about the toxicity of the pesticides used. Arguably, the worst culprits, Dicofol, Dinocap, Methomyl, and Monocrotophos, are now banned. However, India’s leading insecticide is chlorpyriphos (14% of the market share) (8) which has been banned in the UK and EU since the beginning of the decade. The US ban is still a work in progress. (9)

Compared to the chemical concerns in polyester, however, if brands and regulators believe that it is essential to trace cotton, to avoid sourcing fiber tainted by excessive pesticide use, isn’t it equally or even more important to trace polyester to minimise the use of toxic chemicals in all stages of that fiber’s production?

(1) https://ejfoundation.org/news-media/the-casualties-of-cotton
(2) https://baumwollboerse.de/en/competencies/publications/report-on-un/
(3) https://www.pan-uk.org/cotton/
(4) https://www.livemint.com/news/india/the-geography-of-farmer-suicides-11579108457012.html
(5) https://food.chemlinked.com/news/food-news/india-bans-four-pesticides-including-controversial-pesticide-monocrotophos
(6) https://www.mdpi.com/2071-1050/16/17/7839
(7) https://www.vedantu.com/geography/cotton-producing-states-in-india
(8) https://www.mdpi.com/2071-1050/16/17/7839
(9) https://www.etui.org/about-etui/news/two-reprotoxic-substances-banned-in-the-european-union

C) WATER IMPACT OF POLYESTER PRODUCTION

In 2016, the C&A Foundation (now Laudes Foundation) commissioned a study: "Water footprint assessment of polyester and viscose and Comparison to Cotton," published in March 2017.[1] As shown in Table 4, the study found that the total water footprint of polyester fiber (not fabric) was between 51,000 and 71,000 cubic meters of water per tonne of filament or staple.

Table 4: Water Footprint of Polyester

Table 3 – Water footprint of polyester fibres

		Water footprint (m^3/tonne)	
		Minimum	Maximum
Polyester Filament Yarns	Blue	50	52
	Grey	50,640	70,981
	Total	**50,690**	**71,033**
Polyester Staple Fibres	Blue	30	32
	Grey	51,036	71,377
	Total	**51,066**	**71,409**

Table 4: https://waterfootprint.org/resources/WFA_Polyester_and__Viscose_2017.pdf

As we can see in Figure 2, in its 2016 Annual report, however, C&A claimed this study found:
"While water use is relatively low for polyester compared to cotton, the water needed for the crude oil – used to make polyester – and the remaining industrial processes, are the phases that contribute most to polyester's total water footprint: approximately **71 cubic metres per every tonne of polyester fiber produced."**

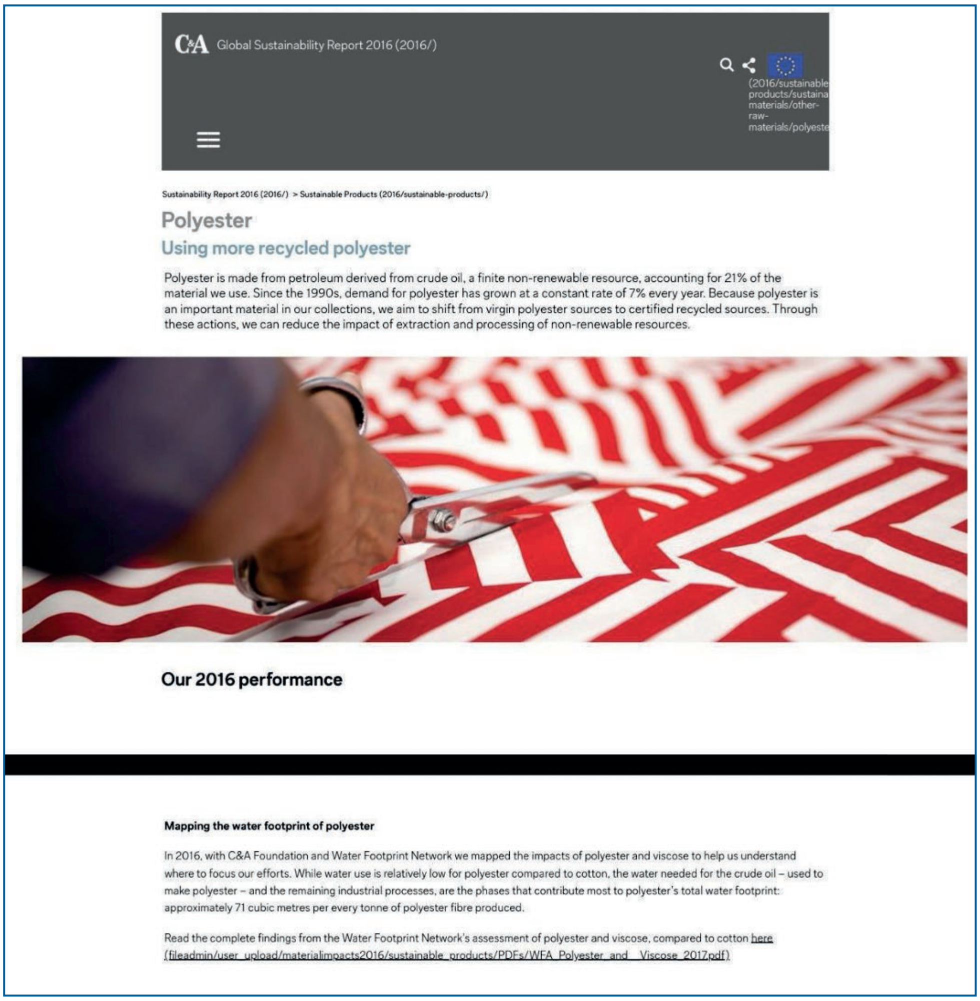
That was incorrect and highly misleading. As shown in Table 4, **it was not 71 cubic meters. It was 71,000 cubic meters.** That's one thousand times greater than the figure given in the C&A sustainability report.

The Water Footprint Network (WFN) report states, "Globally, an average of almost 10,000 litres of water is necessary to produce 1 kilogram of cotton fabric, cotton fabric has a water footprint of only 10,000 liters per kilo, or 10,000 cubic metres per tonne." And the WFN report continues: "Data indicate that **on average polyester has the highest water footprint** ...While cotton represents 67% of the fibers purchased by C&A Europe, it only represents 28% of the combined water footprint for these three fibers. Polyester shows the opposite effect whereby the quantities of fibers purchased is 24% while these fibers represent 68% of the combined water footprint."

That is the diametric opposite of C&A's claim, "water use is relatively low for polyester compared to cotton."

[1] https://waterfootprint.org/resources/WFA_Polyester_and__Viscose_2017.pdf

Figure 2: C&A 2016 Sustainability Report (Screenshot)


C&A Global Sustainability Report 2016 (2016/)

(2016/sustainable products/sustaina materials/other-raw-materials/polyeste

Sustainability Report 2016 (2016/) > Sustainable Products (2016/sustainable-products/)

Polyester

Using more recycled polyester

Polyester is made from petroleum derived from crude oil, a finite non-renewable resource, accounting for 21% of the material we use. Since the 1990s, demand for polyester has grown at a constant rate of 7% every year. Because polyester is an important material in our collections, we aim to shift from virgin polyester sources to certified recycled sources. Through these actions, we can reduce the impact of extraction and processing of non-renewable resources.

Our 2016 performance

Mapping the water footprint of polyester

In 2016, with C&A Foundation and Water Footprint Network we mapped the impacts of polyester and viscose to help us understand where to focus our efforts. While water use is relatively low for polyester compared to cotton, the water needed for the crude oil – used to make polyester – and the remaining industrial processes, are the phases that contribute most to polyester's total water footprint: approximately 71 cubic metres per every tonne of polyester fibre produced.

Read the complete findings from the Water Footprint Network's assessment of polyester and viscose, compared to cotton here (fileadmin/user_upload/materialimpacts2016/sustainable_products/PDFs/WFA_Polyester_and__Viscose_2017.pdf)

Figure 2: The C&A 2016 Sustainability Report has been deleted. This screenshot is from the authors' records. Copy available upon request.

Astonishingly, not one of fashion's many sustainability experts noticed the discrepancy between the report and C&A's claims. Cotton is grown in water-scarce regions because, as a xerophyte, a plant that can survive with very little water, cotton is the best-adapted cash crop for the conditions. The same cannot be said for oil and gas extraction. Iran, for instance, is so short of water that, in July 2025, without rain, water supplies to the national capital, Tehran, were predicted to run out in a matter of months.[1]

We would also note that the results presented in the WFN study were based on onshore oil production. The report noted: "Polyester may also be produced from other raw materials such as gas and, more importantly, unconventional resources. Shale gas is a rapidly growing sector, particularly in the USA and China, and this is likely to dominate the market in the future, becoming a major source for all petroleum-based products, including polyester."

Does shale production - fracking - have the same water footprint as conventional onshore extraction? The answer is no. The water footprint of fracking is far, far higher.

Modern high-volume hydraulic fracturing, or fracking, is a technique used to enable the extraction of natural gas or oil from shale and other impermeable rock formations. Large quantities of water, chemicals, and sand are blasted into these formations at pressures high enough to crack the rock - hence the name fracking - allowing the trapped oil and gas to flow to the surface.[2]

(1) https://www.nytimes.com/2025/12/19/opinion/tehran-iran-water-drought-crisis.html

(2) https://www.nrdc.org/stories/fracking-101

The New York Times (NYT) published an extensive analysis of the water impact of US fracking in September 2023. (1) The NYT analysis found that "Giant new oil and gas wells that require astonishing volumes of water to fracture bedrock are threatening America's fragile aquifers." Specifically, the NYT found that US fracking wells had increased their water usage sevenfold since 2011, totalling about 1.5 trillion gallons of water (5.7 billion cubic meters), much of it from aquifers. (2) Moreover, a 2016 report found that nearly 60 per cent of the 110,000 wells fracked between 2011 and 2016 were in regions with high or extremely high water stress. (3)

In this context, it is noteworthy that C&A and the C&A foundation - now Laudes Foundation - are both part of the Brenninkmeijer family enterprise and their Cofra business ventures. (4) Family-owned for six generations, COFRA has investments in many areas. (5) These include Bregal Investments, (6) and Bregal Energy, (7) "a private equity fund broadly focused on the North-American energy sector. Bregal Energy targets equity investments of up to $100 million to support growth-stage companies and the deployment of proven technologies across the North American energy sector." (8)

Bregal Energy (BE) has been active in North American fracking through investments for more than a decade. For example, BE invested an undisclosed amount in Inflection Energy in 2012. (9) Charges were filed against Inflection Energy by the Pennsylvania Office of Attorney General in November 2019, for allowing 63,000 gallons of wastewater from a hydraulic fracturing site to pollute a nearby tributary in 2017. (10)

Grey water in fracking is not grey in the traditional sense. Flowback is the initial surge of injected fluids returning to the surface shortly after the fracturing process. Produced water is the naturally occurring formation water that also returns with the oil and gas, mainly during the later stages of production. FPW that returns to the surface is generally not treated and restored to the source. Rather, it is disposed of as waste. The most common disposal method is underground injection. (11)

As the NYT put it: "Fracking companies are pulling more water out of the ground, and then, after the fracking process, they must treat or dispose of millions of gallons of contaminated water, removing it from the natural water cycle".
In the Permian Basin in Texas, the largest oil field in the USA, the State of Texas estimates that only 15% of fracking consumption is recycled water. (12)

A similar situation applies in Western Canada.
Stand Earth (SE) reports that in 2024, oil and gas companies in British Columbia extracted a record six billion litres of freshwater, an increase of over 800 million litres, or 16%, since 2022. (13) As SE notes, "Each fracking well uses between five million and 30 million litres of water. After the fracking process is complete, the wastewater that returns to the surface is so toxic that it cannot be returned to the water cycle. Water treatment for fracked water is not required in B.C., so the freshwater that fracking uses – taken from rivers and lakes – is gone forever." (14)

Similarly, the 2022 Compendium study referenced in the section on chemicals in polyester production observes, "Each day in the United States, more than two billion gallons of pressurized fracking fluids are pumped underground for the purpose of extracting oil and gas or, after the fracking is finished, to inject the extracted wastewater into any of more than 187,000 disposal wells across the country."

(1) https://www.nytimes.com/interactive/2023/09/25/climate/fracking-oil-gas-wells-water.html
(2) https://www.nytimes.com/interactive/2023/09/25/climate/fracking-oil-gas-wells-water.html
(3) https://www.ceres.org/resources/reports/hydraulic-fracturing-water-stress-water-demand-numbers
(4) https://www.cofraholding.com/media/wmqlpfvu/laudes-foundation-press-release.pdf
(5) https://www.cofraholding.com/
(6) https://www.cofraholding.com/en/businesses/
(7) https://pitchbook.com/profiles/investor/10708-39#investments
(8) https://www.bregal.com/media/k21oftky/bregal_2018-19-ri-report-final.pdf
(9) https://www.hartenergy.com/news/bregal-energy-increases-investment-inflection-energy-71766
(10) http://www.paenvironmentdigest.com/newsletter/default.asp?NewsletterArticleID=49928&SubjectID=2#:~:text=%E2%80%9CAny%20company%20that%20endangers%20those,Pennsylvania%20Office%20of%20Attorney%20General
(11) https://fracfocus.org/learn/hydraulic-fracturing
(12) https://www.nytimes.com/interactive/2023/09/25/climate/fracking-oil-gas-wells-water.html
(13) https://stand.earth/press-releases/paper-fracking-bc-freshwater-water-grab-drought-peace/
(14) https://stand.earth/press-releases/paper-fracking-bc-freshwater-water-grab-drought-peace/

As that study points out, water use in U.S. fracking operations has more than doubled since 2016, and "these fracking-related activities have depleted or contaminated water resources, including drinking water sources....The water used for fracking that remains in the shale formation is permanently lost to the hydrological cycle." (1)

If water does not return to the watershed. It is effectively consumed. This should show up in LCAs and so in polyester's purported impact. It doesn't.

Both the EU Product Environmental Footprint (PEF) and the Worldly Higg MSI (2) claim that the water impact of polyester is insignificant. As far as fracked feedstock is concerned, that is demonstrably incorrect.

As to the role that fracking now plays in the global supply of oil and gas, we have already noted, and as shown in Figure 3, in 2023, the US produced more crude oil than any country ever. (2)

Figure 3: Average Annual Crude Oil and Condensate from the Top Three Global Producers, 2013–2023

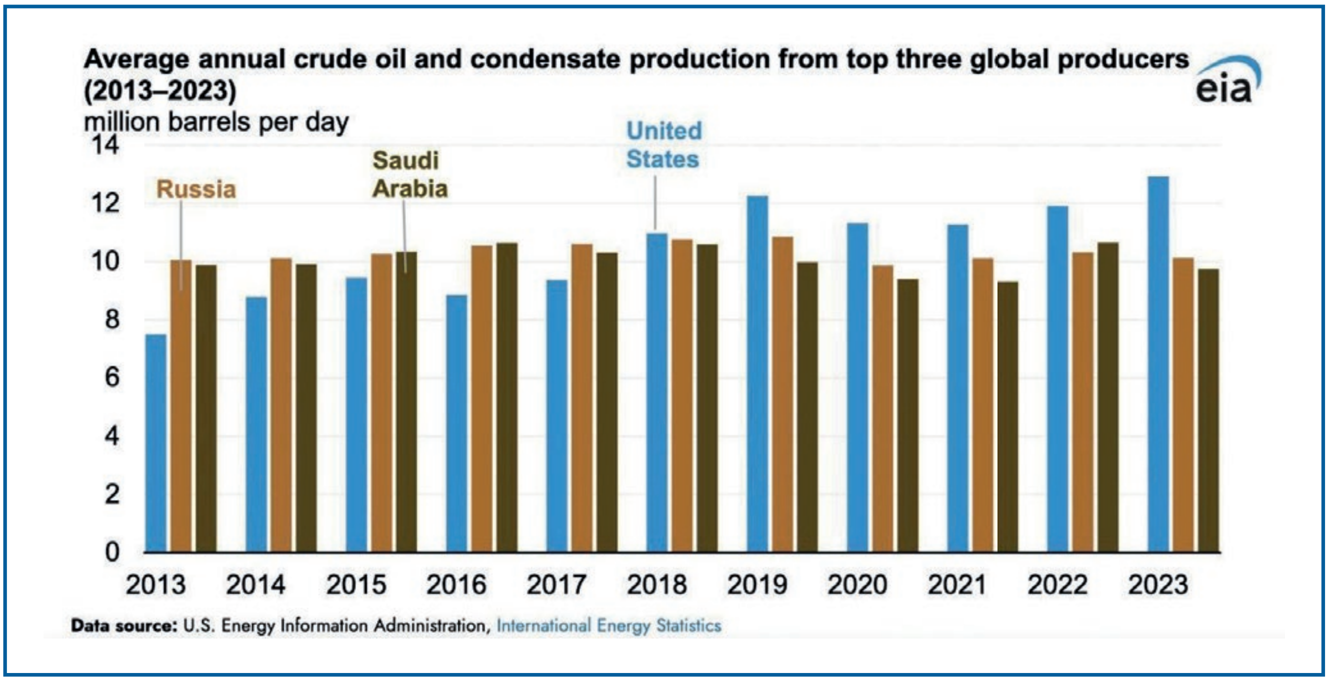


Figure 3: https://www.eia.gov/todayinenergy/detail.php?id=61545#

Moreover, almost 65% of 2023 US crude oil (3) and almost 80% of 2023 US dry natural gas (4) were obtained from shale and tight oil formations. Twenty years earlier - and you will see why this matters in section 3 - it was less than 7%. (5)

This share is expected to increase, and not just in the USA. Currently, other than the United States, only Canada, China, and Argentina produce shale gas or shale oil commercially. (6)

(1) https://psr.org/wp-content/uploads/2022/04/compendium-8.pdf

(2) Please note in their RoR (see Annex 1), Cascale made the following observation:"The report incorrectly refers to the "Worldly Higg MSI" several times throughout the document. This is incorrect framing. While available through the Worldly platform, Cascale owns and stewards the Higg MSI methodology".
We refer to it as the Worldly MSI for the reader's convenience, as the MSI scores can no longer be found on the Cascale website, only on the Worldly website.
The reader should, however, retain this distinction when reading the remainder of this report.

(3) https://www.eia.gov/tools/faqs/faq.php?id=847

(4) https://www.eia.gov/tools/faqs/faq.php?id=907&t=8#:~:text=In%202023%2C%20about%2078% 25%20(,production%20was%20from%20shale%20formations.&text=Last%20updated:%20September%2019%2C%202024;%20preliminary%20data

(5) https://usafacts.org/articles/how-much-oil-is-produced-in-the-us/

(6) https://sgkplanet.com/en/in-what-countries-is-fracking-done

In 2014, shale gas accounted for approximately 4% of total Canadian natural gas production, while tight gas accounted for 47%. By 2035, tight and shale gas production together are expected to represent 80% of Canada's natural gas production. Similarly, in 2014, tight oil accounted for more than 10% of Canada's total crude oil production. By 2030, moderate growth in light oil production from tight oil is expected to offset a decline in conventional heavy oil production. However, the development of Canadian tight oil reservoirs is still in its early stages, and the extent to which they can generate viable production is uncertain. (1)

Tight oil and gas, incidentally, are a form of fracking. "Shale and tight resources are hydrocarbons (crude oil, natural gas, and natural gas liquids) found in tight reservoirs – rocks with pores so small or poorly connected that the oil and natural gas cannot flow through them easily. Hydrocarbons found in these types of reservoirs are referred to as "tight gas" or "tight oil" and usually require the combination of two technologies – horizontal drilling and hydraulic fracturing (sometimes referred to as "fracking") to release the hydrocarbons and allow them to flow to the well at commercial rates. Shale is a common type of tight reservoir that is composed of extremely fine-grained, sedimentary rock and may contain oil or natural gas – referred to as "shale oil" or "shale gas". (2)

And it is not just Canada and the USA that plan to expand fracking operations.

China is determined to reduce import dependence and enhance energy security. It is estimated that China's shale gas reserves are 50% larger than those of the USA. (3) The Energy Information Agency (EIA) estimates that shale gas accounted for just 12% of China's domestic natural gas production in 2023, as geological and cost issues have hampered more rapid development. (4) But Chinese technology is advancing rapidly, and it has been reported that in 2023, the China National Petroleum Corporation produced natural gas from shale in the Lower Cambrian formation in the Sichuan Basin at a depth exceeding 14,760 feet (4,500 meters). Commercially viable natural gas has never previously been produced from such a deep formation. (5)

To return to water impact, unlike Canadian and US production, China has a good track record on the use of flowback and produced water (FPW). Since 2020, it is estimated that 80% ~ 90% of the FPW has been reused, accounting for 29% to 35% of the annual water usage for hydraulic fracturing. However, it remains the case that water consumption is a concern. Indeed, the water use intensity for shale gas extraction in China ranges from 7 to 25.4 L/GJ, which is significantly higher than that of the U.S. This disparity is largely due to the lower Estimated Ultimate Recovery of shale gas wells in China. (6) As fracking expands into less accessible areas and deeper formations, water consumption per unit extracted will likely increase.

By the same token, Saudi Arabia is in the early stages of its own shale exploitation with the vast (17,000 km2) Jafurah Gas Field, albeit this will apparently use seawater (the chemical concerns remain). (7) Russia, it would seem, also plans to enter the field.

The claim, embedded in most indices - including the EU and French PEFs and the Worldly Higg MSI - that polyester production has minimal water impacts (see section 3), is inconsistent with the facts.

(1) https://natural-resources.canada.ca/energy-sources/fossil-fuels/shale-tight-resources-canada
(2) https://natural-resources.canada.ca/energy-sources/fossil-fuels/shale-tight-resources-canada
(3) https://www.gem.wiki/China_and_fracking#:~:text=China's%20annual%20output%20of%20shal e,50%25%20larger%20than%20our%20own
(4) https://www.eia.gov/todayinenergy/detail.php?id=63284
(5) https://www.eia.gov/todayinenergy/detail.php?id=63284
(6) https://pubmed.ncbi.nlm.nih.gov/37890628/
(7) https://www.aramco.com/en/news-media/elements-magazine/2022/jafurah-the-jewel-of-our-unconventional-gas-program

D) WATER IMPACT OF COTTON CULTIVATION

As to the purported water impact of cotton, the first thing to note is that the water impact in indices (both EU PEF and the MSI, for example) is generally weighted by a scarcity factor. The most commonly used water weighting system is called AWARE. The accuracy of this weighting is highly contested, and so a question mark is raised over the purported water consumption in cotton from the outset. In other cases – Kering's EP&L and potentially, the French PEF – [1] , a water footprint may be employed. [2] The water footprint of any product is the total water involved in its production, including rainwater (green), irrigation (blue), and wastewater (grey). The two systems are often muddled, and sustainability "experts" switch between them as if they were the same.

If we were to apply a scarcity weight to the water used in fracking in many areas of the USA, Canada, and China, consumption would appear far higher than the nominal value. On the other hand, the water footprint for cotton includes predominantly rainwater. The local population cannot drink or bathe in rainwater falling on fields, and if the field was not planted with cotton, the water would be taken up by some other crop, or by natural ecological succession. The C&A study referenced earlier compared the water footprints of polyester and cotton. If we consider the water impact of cotton, excluding rainwater, the total is considerably less than the 10,000 litres per kilogram of cotton fabric, or 10,000 cubic metres per tonne, stated earlier.

It is also important to remember that rain and land are frequently the only resources available to small farmers in much of the Global South. Employing those resources in a manner that yields the highest income and opportunity maximises the welfare of the most disadvantaged, promoting SDGs 1, 2, and 3. The same cannot be said for water consumed/polluted in the polyester supply chain.

As part of the RoR in March 2026, Cascale made the following criticism of our work:
"In Section 2. d) the report states that "The water footprint of any product is the total water involved in its production, including rainwater (green), irrigation (blue), and wastewater (grey)," and "the water footprint for cotton includes predominantly rainwater." These statements are misleading in the context of the paragraph since water consumption (and AWARE scarcity impacts) are based on blue water only." (see Annex 1 for Cascale's full statement).

We repeat and rephrase the first few sentences of this section: the water impact in the MSI is weighted by a scarcity impact - a notion of water availability devised by LCA practitioners called Available Water Remaining or AWARE. [3] In other cases (Kering's EP&L and potentially, the French PEF), a water footprint may be employed. Again, we repeat, these systems are not the same and should not be confused. Contrary to Cascale's assertion, the WFN water footprint does include green or rainwater. We quote, for cotton: "Global average water footprint 2495 litres for a shirt of 250 gram 54% green, 33% blue, 13% grey." [4]

It is precisely this that enables Kering to claim that 100% rainfed African cotton has a water cost of €73 to €76 per kilo of material, [5] while Cascale claims that the water impact of cotton made in Africa is almost zero.

The crucial lesson that we can all learn from this discussion is just how subjective impact measurements are. Comparative impacts are presented to the general public as scientific, impartial, and objective. They are not. Purported impacts will vary significantly depending on the methodology selected.

(1) https://www.crdc.com.au/sites/default/files/pdf/French%20PEF.pdf
(2) We had hoped to get clarity on how the French PEF calculates water impact through the RoR process, but while Ecobalyse acknowledged receipt of this paper, they did not, in the end, respond to the RoR.
(3) https://wulca-waterlca.org/wulca/
(4) https://www.waterfogreyotprint.org/resources/interactive-tools/product-gallery/
(5) https://www.veronicabateskassatly.com/read/37th-international-cotton-conference-bremen-sustainability-and-legislation-in-textiles-and-apparel

E) CLIMATE CHANGE IMPACT OF POLYESTER PRODUCTION

The apparel industry has, for years, tried to suggest that factory fibers, unlike farmed fibers, are "standardised", that just one LCA of European polyester production provides "representative data for polyester fiber in general", and that the responsibility lies with natural fibers to provide more good data. (1)

As Figure 4 amply illustrates, simply comparing global emission intensities in power generation tells you that two identical factories, run with identical efficiency but in two different countries, will not have identical production emissions. A factory in France or Italy cannot be representative of the climate impact of a factory in India or China. But Asia is where most polyester in the apparel supply chain comes from. The difference in electricity emissions between France and India is a factor of 16x, and between Italy and Indonesia, it's 2.1x. Furthermore, not all factories are run with equal efficiency, and factories in countries where energy is expensive are more likely to have invested in carbon-mitigating technology than factories in areas where energy is cheap. For example, the ITMF International Production Cost Comparison for 2021 showed that electricity in Italy costs USD 0.16/kWh, and in Indonesia and India, it costs only USD 0.10/kWh. (2)

Figure 4: Comparative Carbon Intensity of Electricity Generation, Select Countries, 2000 to Present

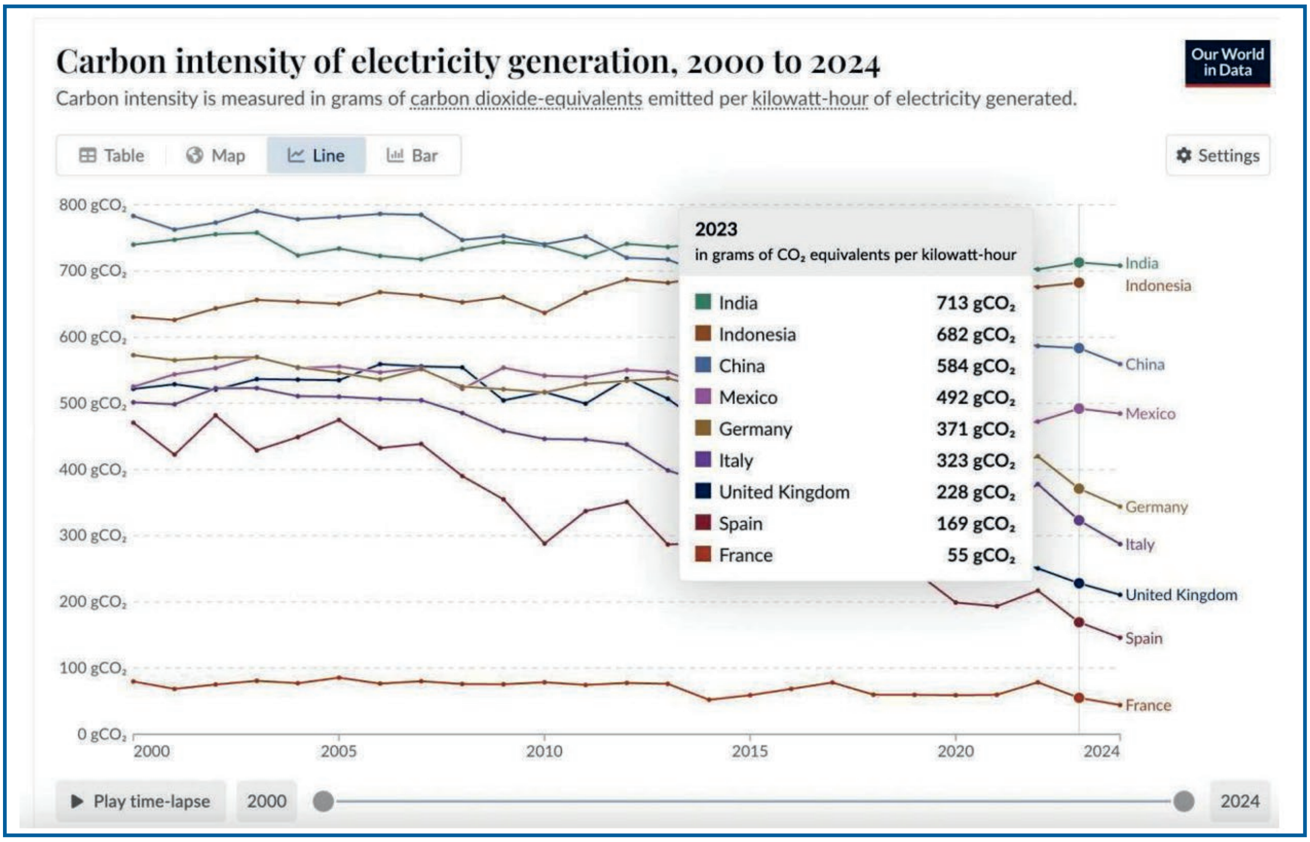


Figure 4: https://ourworldindata.org/grapher/carbon-intensity-electricity?tab=line&country=FRA~EU-27~EU~CHN~IND~ITA~DEU~GBR~ESP~MEX~IDN Screen grab taken 22/07/20

(1) https://ecocult.com/higg-natural-fibers-climate-synthetics-lca/
In their RoR, TE state:" Over the past three years, we have specifically invested in conducting an updated Polyester Life Cycle Assessment (LCA) study, which includes impact data from geographic regions beyond Europe including China, southeast Asia, and North America. The Polyester LCA study is anticipated to be released in 2026 and will go beyond traditional LCA methodology by using our "LCA+" approach to impact. This approach broadens the scope of assessment to include impact areas not typically covered in traditional LCA methodology, to provide a more holistic understanding of impact." Given the importance of polyester in the global supply chain, some might argue this is too little, too late.

(2) https://www.itmf.org/publications/statistics-publications/international-production-cost-comparison-ipcc-2021

Simply because fibers are made in a factory rather than a field does not mean that their emissions and other environmental impacts are standardised.

Looking at polyester specifically, let's start with the feedstock — generally crude oil or natural gas (in China, small amounts of Monoethylene glycol are produced from coal). This, too, will come with vastly different carbon emissions depending on the source location.

As we can see from Table 5, the world's leading producer of oil and gas is currently the USA, with an annual production that is almost as large as the total output of the next two nations — Russia and Iran-—combined. As of February 2025, the USA had 1,709 gas extraction areas, of which 60 were shut in. The next highest was another commercial producer of shale gas, ranked 4th in total global output, Canada, with 708 areas, of which 60 were shut in. As for oil extraction sites, as of the same date, the USA had 1,505, of which 54 were shut in. Again, Canada was the next highest with 1,050 sites and 5 shut in. [1]

Shut in 'plays' or extraction sites are those where operations have temporarily or permanently ceased. One major problem with shale/tight oil wells is that they decline rapidly. "The vast majority of the oil production from a new tight oil well occurs in the first two years of production. In order to maintain or increase production in a shale play, new wells have to be brought on-line at a high rate to replace declining production from older wells.' [2]

The US EPA estimates that there are 4 million abandoned oil and gas wells in the United States alone, and more than 117,000 of those are "orphaned," ie, they are unproductive, uncapped, and no responsible party has been identified to manage leakage or pollution risks. [3] Poorly sealed or orphaned/abandoned sites can leak methane and contaminate groundwater long after production has ceased. The shorter lifespan of fracked wells exacerbates the problem.

Not all, or even most, global petrochemical feedstocks are fracked, but an increasing proportion will be. Further, even within more traditional feedstocks, there are vast differences in processes, and so associated emissions and impacts. Oil companies are not small or even large cotton farms. They cannot be bullied into producing detailed production data by threats to cancel purchases or deny certifications. As we can see from the case of Colorado fracking operations described in section 2.a), regulation notwithstanding, it is almost impossible to determine what is being used in the extraction process, how, and how much.

This is not an excuse not to trace and measure extraction impacts, as brands and their initiatives appear keen to assert. If sources decline to reveal their impacts, the tried and trusted metric is to simply assume that they reflect worst practice. Moreover, what is known about relative production costs does indicate likely associated impacts. We quote David Rundell, in Vision or Mirage: Saudi Arabia at the Crossroads. [4]
"Most estimates put average Saudi production costs between US$3 and $5 a barrel. The average cost of production in the United States, including shale and offshore wells, is roughly $40 a barrel; and Canadian oil-sands production costs are closer to $100 a barrel." Not only are Saudi wells relatively shallow, and in many cases, flow from natural pressure, but there are no mountains to cross or long pipelines to build and maintain before the fuel even enters a tanker. With every additional step required, there will not just be additional cost but also additional environmental impact.

And the potential difference between impacts does not end there. Traditional oil extraction also releases natural gas. This associated gas is often flared wastefully. Indeed, the World Bank has calculated that " the amount of gas currently flared each year – about 151 billion cubic meters (bcm) – could, if supplied to power generation facilities, power the whole of sub-Saharan Africa." [5]

Associated gas can be captured. It has been in Saudi Arabia since the mid-seventies, when the introduction of the Master Gas System obliged Aramco's American owners to invest the equivalent of US$40 billion in today's money, in capturing previously flared methane to fuel desalination and power plants as well as to provide ethane for Saudi Arabia's burgeoning petrochemical industry." [6]

1. https://globalenergymonitor.org/projects/global-oil-gas-extraction-tracker/summary-tables/
2. https://www.resilience.org/stories/2024-07-03/the-status-of-u-s-oil-production-2024-update-everything-shines-by-dimming/#:~:text=The%20five%20prominent%20shale%20oil,of%20total%20U.S.%20oil%20pro duction
3. https://www.nbcbayarea.com/news/local/climate-in-crisis/climate-in-crisis-orphaned-gas-oil-wells/3423903/#:~:text=Kari%20Hall%20reports.-,The%20Environmental%20Protection%20Agency%20estimates%20that%20there%20are%20a pproximately%204,manage%20leakage%20or%20pollution%20risks
4. https://www.bloomsbury.com/uk/vision-or-mirage-9781838605933/
5. https://www.worldbank.org/en/programs/gasflaringreduction/gas-flaring-explained
6. https://www.bloomsbury.com/uk/vision-or-mirage-9781838605933/

Oil feedstock from Iraq, or Iran, where most gas is still flared —and here we note that in 2023, Iran flared more natural gas than any country except Russia — cannot have the same climate impact as Saudi oil. (1) Using captured methane as a feedstock cannot have the same environmental impact as using oil or fracked gas, where the associated methane was flared. PET produced by Sabic (Saudi Basic Industries Corporation) (2) cannot have the same emissions as PET produced by Reliance Industries or Indorama. It is nonsense for the apparel and LCA industries to suggest that there is something standardised and uniform about global PET production emissions, so there is no need to trace feedstock.

Indeed, information and current data on flaring and associated emissions are freely available on the Energy Institute (EI) website. (3) There is some flaring from natural gas included, but according to the World Bank, "At the majority of gas fields, there is little routine flaring." (4)

The vast majority of routine flaring occurs in oil production.

The EI database indicates that the carbon dioxide emissions from US flaring totaled 5.4 million tonnes in 2001, and the reason that year was selected will be apparent in section 3. But in 2024, they had risen to 24.7 million tonnes. Over the same period, US oil production increased from 344.5 million tonnes to 857.9 million tonnes. Meaning that between 2001 and 2024, US flaring emissions per tonne of oil rose from 0.016 to 0.029, or by 80%. In 2001, Saudi Arabia was the world's leading oil producer. (5) Saudi emissions from flaring are estimated at 0.5 million tonnes of CO_2 in 2001 (falling from a high of 75.6 million tonnes in 1980), rising to 5.9 million tonnes in 2024. Saudi oil production increased from 427.7 million tonnes in 2001 to 510.2 million tonnes over the same period. In other words, Saudi flaring emissions increased from 0.0012 tonnes of carbon dioxide per tonne of oil in 2001 to 0.012 in 2024. That is an increase of 10x. Similarly, flaring-associated carbon emissions of the world's other major oil supplier, Russia, increased from 9.8 million tonnes of carbon dioxide in 2002 (2001 data n.a.) to 57.8 million tonnes in 2024. Russian production rose, but proportionately less, from 351.7 million tonnes of oil in 2001 to 526.4 million tonnes in 2024. This meant Russian flaring emissions rose from 0.029 tonnes per tonne of oil to 0.110 tonnes per tonne over the same period. That is an increase of 3.8x. It is, furthermore, 9x greater than Saudi flaring emissions per tonne, and 3.8x greater than US flaring emissions per tonne of oil produced. (6) (NB: the methane-to-CO_2e factor employed by the Energy Institute is a 100-year Global Warming Potential (GWP) of 25.)

Claiming that flaring emissions in 2001 are representative of the emissions in 2024 is unscientific. And please note, we are just looking at flaring. Leaks in gas production are not included, and these, too, are known to have soared. Leaks can start and stop irregularly, in different places along the natural gas supply chain, making them hard to track. The EPA estimates that in the USA, ≈ 1% of total natural gas production is leaked. But at least one study has suggested that, based on data from 2010 to 2019, methane emissions were 70 percent higher than U.S. government figures. (7)

Indeed, measurement of emissions from both oil and natural gas production is highly uncertain. As a study published in Nature in March 2024 put it: "the true scope of methane emissions from energy production has yet to be quantified. We integrate approximately one million aerial site measurements into regional emissions inventories for six regions in the USA, comprising 52% of onshore oil and 29% of gas production over 15 aerial campaigns..... The six-region weighted average is 2.95%, or roughly three times the national government inventory estimate. Only 0.05–1.66% of well sites contribute the majority (50–79%) of well site emissions in 11 out of 15 surveys." (8)

Given the apparel sector's obsession with tracing cotton production to weed out irresponsible farming practices, similar diligence would seem essential in polyester. The majority of the emissions (50–79%) came from less than 2% of the well sites.

(1) https://www.eia.gov/international/analysis/country/IRN
(2) https://www.sabic.com/en/products/polymers/polyethylene-terephthalate-pet
(3) https://www.energyinst.org/statistical-review/resources-and-data-downloads
(4) https://www.worldbank.org/en/programs/zero-routine-flaring-by-2030/qna#7
(5) https://www.aei.org/carpe-diem/chart-worlds-top-ten-oil-producing-countries-1965-to-2018/
(6) https://www.energyinst.org/statistical-review/resources-and-data-downloads
(7) https://climate.mit.edu/ask-mit/how-much-does-natural-gas-contribute-climate-change-through-co2-emissions-when-fuel-burned#:~:text=Methane%20is%20the%20main%20component,poorly%20quantified%2C%E2%80%9D%20Plata%20says
(8) https://www.nature.com/articles/s41586-024-07117-5

As to the relative contribution of oil and gas to total feedstock, according to the Global Energy Monitor (1) total annual global oil and gas production, as of March 2026, was 55.97 billion boe/year (barrels of oil equivalent), of which almost 56% was liquid production, ≈25,000 boe (44.7%) were in the form of gas, and the remaining 1.5% was unspecified hydrocarbons. (2)

The top producers are shown in Table 5.

Table 5: 2025/26 Annual Global Oil and Gas Production, Top 13 Nations

A	B	C	D	E
Oil and Gas Production				
Global Oil and Gas Extraction Tracker, March 2026				
Global Energy Monitor				
Country/Area	**Gas Production (bcm/y)**	**Liquids Production (million bbl/y)**	**Unspecified Hydrocarbons Production (million boe/y)**	**Total Production (million boe/y)**
United States	1264	5735	22	13192
Russia	581	2358	3	5780
Iran	332	1823	0	3776
Canada	221	2162	0	3461
Saudi Arabia	3	3261	0	3278
China	231	1171	0	2527
Iraq	9	1816	0	1872
Qatar	222	431	0	1739
Brazil	58	1276	0	1616
Norway	127	807	0	1556
Algeria	80	781	40	1291
Nigeria	36	912	5	1132
United Arab Emirates	5	967	44	1042

Table 5: https://docs.google.com/spreadsheets/d/1JHt24Rmm6e0DyeTSqvqH1i9nJ876iYrq6X1InCAHcf0/edit?gid=296428072 #gid=296428072

To obtain data representing 53% of global oil and gas production (approximately 29.5 billion barrels equivalent), brands and initiatives would need to measure only the top 5 producers. The Cotton Incorporated 2016 LCA, which has been relied upon to indicate production emissions for cotton for almost a decade, covered 67% of global cotton production. (3) To obtain similarly representative coverage of global oil and gas emissions (37.5 billion barrels equivalent), brands and initiatives would only need to measure data from the top 9 producers.

As to where to get some of this data, funded by a grant from Google, Climate Trace is a non-profit coalition of over 100 universities, scientists, and AI experts building a timely, open inventory of exactly where greenhouse gas emissions are coming from. (4)

Using artificial intelligence and machine learning to analyze over 90 trillion bytes of data from more than 300 satellites and 11,000 sensors, as well as numerous additional sources, as shown in Figure 5, Climate Trace provides current data on emissions associated with oil and gas production by major location. (5)

"To ensure alignment with financial and government reporting standards, the methane to CO_2e factor is a 100-year Global Warming Potential (GWP) of 25, recommended by the IPCC in AR4." (6)

(1) https://globalenergymonitor.org/projects/global-oil-gas-extraction-tracker/summary-tables/
(2) https://docs.google.com/spreadsheets/d/1JHt24Rmm6e0DyeTSqvqH1i9nJ876iYrq6X1InCAHcf0/edit?gid=296428072#gid=296428072
(3) https://resource.cottoninc.com/LCA/2016-LCA-Full-Report-Update.pdf
(4) https://climatetrace.org/about
(5) https://climatetrace.org/explore/#admin=&gas=co2e&year=2024&timeframe=100&sector=fossil-fuel-operations,oil-and-gas-production&asset=
(6) https://www.energyinst.org/ data/assets/pdf_file/0007/1658077/Statistical-Review-of-World-Energy.pdf

Figure 5: Climate Trace 2024 Oil and Gas Production, 9 Largest Emitters (CO_2e 100yr)

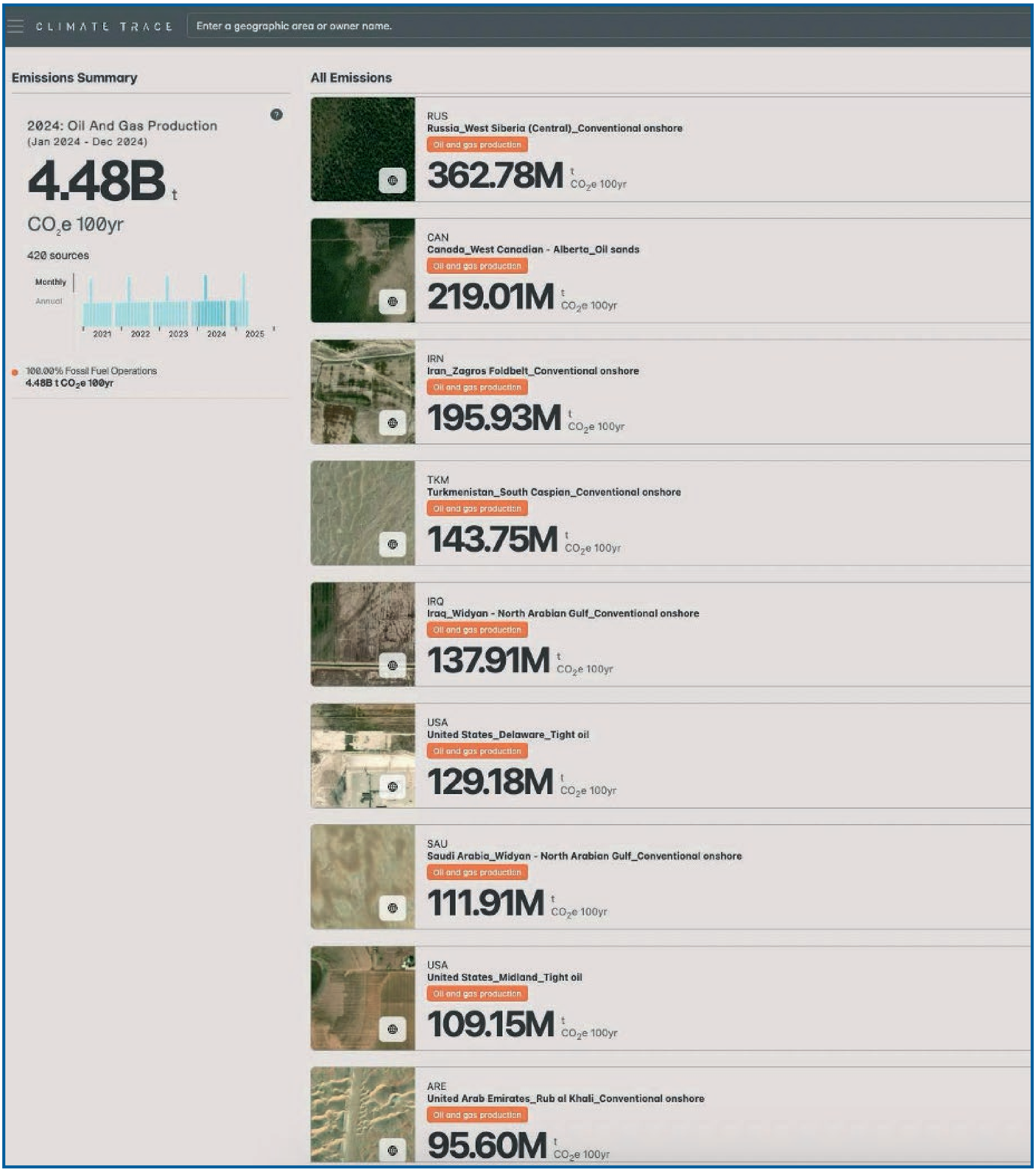


Figure 5: https://climatetrace.org/explore/#admin=&gas=co2e&year=2024&timeframe=100&sector=fossil-fuel-operations,oil-and-gas-production&asset= Screenshot taken 09/08/2025

Here we note that, as the Energy Institute (EI) points out, it is not just the quantity of emissions that is uncertain, as the Nature article referenced earlier observed, it is also the impact of any given quantity of methane. We quote: "There is a wide range of uncertainty with respect to both current estimates of methane emissions **and the global warming potential of methane emissions."** (our bold) [1]

(1) https://www.energyinst.org/ data/assets/pdf_file/0007/1658077/Statistical-Review-of-World-Energy.pdf

The 100-year GWP is based on the energy absorbed by a gas over 100 years; the 20-year GWP is based on the energy absorbed over 20 years. The latter prioritizes gases with shorter lifetimes because it does not consider impacts that happen more than 20 years after the emissions occur. Because all GWPs are calculated relative to CO_2, GWPs will be larger for gases with lifetimes shorter than that of CO_2, and smaller for gases with lifetimes longer than CO_2. [1]
For example, CH4 (methane), which has a short lifetime, has a 100-year GWP of 25–28 for non-fossil emissions and 30 for fossil emissions, which is much lower than the 20-year GWP of 81–83. [2]

Climate Trace provides emissions in both CO_2e 100yr and 20yr. As shown in Figure 5, as of August 10, 2025, on the Climate Trace website, total CO_2e 100yr emissions from oil and gas production at 574 sites (including 8 with no data) were shown as 4.48 billion tonnes. A Russian oil/gas field had the highest emissions, followed by fields in Canada, Iran, Turkmenistan, and Iraq, in that order. Switching to CO_2e 20-year increased the total to 8.65 billion tonnes, and while the Russian oil/gas field still has the highest emissions, it is now followed by Turkmenistan, Iran, Canada, and the USA.

This illustrates a problem common to all impact measurements, including in LCAs: the system chosen - a subjective decision - will heavily influence the outcome.

And that's not all. When we first downloaded the Climate Trace charts in early July 2025, they showed different values. As shown in Figure 26 in Appendix 3, in July, Climate Trace reported that 2024 global oil and gas extraction generated a lower amount: 3.96 billion tonnes CO_2e over 100 years, or 6.96 billion tonnes of CO_2e over 20 years. And at that point, using CO_2e 100yr, an Iranian oil/gas field had the highest emissions (just), followed by fields in Russia, a second Iranian field, and Canada. While using CO_2e 20yr, a Russian oil/gas field was shown to have the highest emissions, followed by a field in Iran, a second site in Iran, and Saudi Arabia.

This highlights a highly pertinent concern: science advances. On July 31, 2025, Climate Trace updated all historical oil and gas production with new modeling on lifecycle emissions and changes to input data sources. Sticking to the use of CO_2e 100yr, as recommended by the IPCC in AR4, the result, as we have seen, was a 13% increase in total emissions.

Moreover, if in July 2025, you had said global oil and gas production generates roughly 4 billion tonnes of CO_2 annually, you would still have been broadly correct in August. If, on the other hand, you had claimed that the highest emissions come from the 'Iran_Rub al Khali_Conventional shelf', with a total of 265.55 million tonnes, while correct in July, you would have been wrong in August. Revised calculations show that 'Iran_Rub al Khali_Conventional shelf' generated only 148.54 mt CO_2e, and was ranked 9th, not first. The revised emissions are only 56% of the previous estimate.

And it didn't end there. While finalising this paper for review, we checked the source links. On December 12, 2025, as shown in Figure 28 in Appendix 3, total 2024 oil and gas production emissions had fallen back down to 3.95 billion tonnes CO_2e over 100 years. A Russian oil/gas field still had the highest emissions, but it was now followed by fields in Iran, Canada, Saudi Arabia, and Iraq, in that order. We checked again in March 2026. Total 2024 oil and gas production emissions were listed as 3.96 billion tonnes CO_2e over 100 years. The top 5 emitters remained unchanged. As for 2025, as of March 14, 2026, Climate Trace recorded a rise in global oil and gas production emissions to 4.12 billion tonnes CO_2e over 100 years. The top 5 emitters were the same as the previous year, but the annual emissions from Russia - West Siberia, apparently, rose from 268.6 million tonnes in 2024 to 302.3 million tonnes in 2025.

As Climate Trace points out, and we quote: "Revisions to existing Climate TRACE data are common and expected. They allow us to take the most up-to-date and accurate information into account. As new information becomes available, Climate TRACE will update its emissions totals (potentially including historical estimates) to reflect new data inputs, methodologies, and revisions." [3]

1. https://www.epa.gov/ghgemissions/understanding-global-warming-potentials
2. https://ghgprotocol.org/sites/default/files/2024-08/Global-Warming-Potential-Values%20%28August%202024%29.pdf
3. https://climatetrace.org/news/climate-trace-releases-september-2025-emissions-data

We found all these modifications frankly disturbing. Not because they are unjustified or unscientific, quite the contrary. But because they made us aware of just how foolhardy it is to claim that impact calculations at one point in time can be used with complete confidence to direct detailed purchasing and consumption decisions for years thereafter. Even for something as seemingly straightforward as carbon emissions from oil and gas production, Climate Trace needed to revise its estimates. As we will see in the next section, in agricultural production, we are trying to evaluate how animals, soil, and plants convert sun, water, nutrients, and feedstuffs into emissions, and then convert those into carbon equivalents. The scope for error is magnified accordingly. Broad claims are reasonably robust; detailed assertions about the relative impacts of individual production sites, let alone products, are not.

We cannot understand how apparel sustainability experts, brands, and now legislators can scientifically and ethically promote the notion that we have sufficient information to determine relative product impacts and advise consumers and the electorate accordingly. Tracing brands' sourcing and so emissions, for reporting purposes, is no doubt helpful, and if these estimates have to be revised down the line, that is hardly unusual and causes little lasting damage. Using emissions and other impact estimates that turn out to be wrong to alter purchasing decisions, and so the incomes and opportunities of some of the most disadvantaged communities on the planet, is a very different matter. The damage to those individuals is irreversible and irreparable.

Returning to the topic of this report and the question of relating oil and gas production emissions to polyester output, it is beyond the scope of this paper to attempt this, but it could obviously be done. For instance, Western Siberia was number 2 in 2024 production emissions in Carbon Trace's early July ranking. At the end of July and mid-December 2025, it was ranked number 1. For 2025, Climate Trace's estimates still rank Western Siberia number 1. Western Siberia accounts for 90% of Russia's natural gas production and is the main production region for crude oil and condensate [1] using Western Siberia data as a proxy for all Russian production would not be far off and would err on the side of caution.

We would also point out that not only is Russian and Iranian oil and gas production associated with high emissions, but it is also currently subject to embargoes. Following Russia's invasion of Ukraine in 2022, several countries imposed targeted measures on Russia's energy sector. In January 2025, the USA and UK imposed additional measures supporting price caps and export bans on oil and petroleum products from Russia. The EU adopted an 18th package of restrictions in July 2025 that lowered the existing price cap on Russia's oil exports and increased measures intended to limit the circumvention of capped oil prices by Russia's shadow fleet. [2]

Similarly, Iran has been subject to on/off sanctions for many years, most recently reimposed in 2018. After Russia invaded Ukraine in February 2022, and European countries reduced their imports of Russian oil, Russia significantly discounted its crude oil price. China's independent refiners began purchasing more crude from Russia, displacing some of Iran's. Judging by tanker tracking data, China took nearly 90% of Iran's crude oil and condensate exports in 2023 (in 2017, it was 25%). Imports from Iran accounted for about 5% of the oil supply in China in 2024. [3] Because of US sanctions and because Russian oil supplies are cheaper, exports of oil from Iran to India fell to nearly zero as of 2024. [4] Indian imports of Russian oil, on the other hand, have soared.
(As of March 2026, Iran is at war with the US and Israel, and obviously, Iranian oil exports are at least temporarily halted. It is impossible to say at this writing what the long-term impacts of the war will be on Iranian oil shipments. At least in the short term, most experts see the war as a boon for Russia)

The result, as we see in Appendix One, is that sanctions notwithstanding, significant quantities of both Russian and Iranian oil nonetheless enter the UK, USA, and EU each year, in the form of polyester. As long as sanctions remain in place, there is as much need to trace polyester to avoid using Russian or Iranian feedstock as there is to trace cotton to avoid using Xinjiang cotton.

(1) https://www.eia.gov/international/content/analysis/countries_long/russia/
(2) https://www.eia.gov/international/content/analysis/countries_long/russia/
(3) https://www.eia.gov/international/analysis/country/IRN
(4) https://www.eia.gov/international/content/analysis/countries_long/russia/

Returning to emissions, however, it's not just feedstock extraction emissions that can vary significantly by location. Refineries, too, can generate very different emissions per boe (barrel of oil equivalent) processed. There are 1,200+ refineries in the world, (1) but for various reasons, not all are active. Across Africa, and in Nigeria in particular, many refineries remain idle or underperforming. (2) However, even the USA had 130 operable refineries in 2022, but 5 were inactive. For 2025, there were 132 operable refineries in the US, and only 1 was idle. (3) Currently, the global total number of active refineries appears to be around 825. Global CDU (crude distillation unit) capacity is expected to grow by 15% during 2023-2027. By region, Asia is expected to have the highest CDU capacity in 2027, followed by North America and the Middle East. (4)

Climate Trace ranks the emissions of 728 oil and gas refineries worldwide (albeit 36 refineries were without data, rising to 52 as of 14 March 2026). These generated a total of 997.27 Mt CO_2e 100yr in 2024. Before the July 31 revision, it was 996.34. By March 2026, the 2024 total had been further reduced to 986.7 Mt. As we can see from Figure 6, the refinery that generated the most emissions was Reliance Industries' Jamnagar Refinery in India. This generated 19.30 Mt CO_2e 100yr in 2024 (reduced to 18.97 as of 14 March 2026). As shown in Figure 27 in Appendix 3, that impact is unchanged from the previous estimate and was equal to the world's 2nd- and 3rd-largest emitters combined (in mid December 2025, Jamnagar's emissions had fallen slightly but were still equal to the next 2 combined. As of March 2026, that relationship still holds) This is not entirely surprising as Jamnagar is the world's largest refinery (in fact, it's 2 refineries on the same site) covering 3,000 hectares, with a crude processing capacity of 1.2 million barrels per day. (5) Interestingly, for 2025, Climate Trace estimates that global oil and gas refining emissions fell slightly to 975.18Mt CO_2e 100yr. Jamnagar's emissions, however, apparently increased to 19.05 Mt CO_2e.

Figure 6: 2024 Oil and Gas Refinery Emissions, 8 Most Impactful Global Refineries According to Climate Trace on the next page >>

(1) https://www.globaldata.com/industries-we-cover/oil-gas/?_gl=1*gfc39v*_ga*MzIxMjYwMDkyLjE3NTM1MTMwMDY.*_ga_TDKVNS5N2K*czE3NTUx NjExMjAkbzkkZzEkdDE3NTUxNjE2MzgkajMxJGww-JGgw#

(2) https://guardian.ng/interview/why-africa-struggles-with-idle-refineries-dirty-petrol/

(3) https://www.eia.gov/dnav/pet/pet_pnp_cap1_a_(na)_800_Count_a.htm

(4) https://www.offshore-technology.com/data-insights/global-top-ten-active-oil-refineries/

(5) https://climatetrace.org/news/rpl-jamnagar-the-worlds-largest-oil-refinery#:~:text=The%20RPL%20Jamnagar%20refinery%20is,capital's%20famed%20historic% 20financial%20district.

Figure 6: 2024 Oil and Gas Refinery Emissions, 8 Most Impactful Global Refineries According to Climate Trace

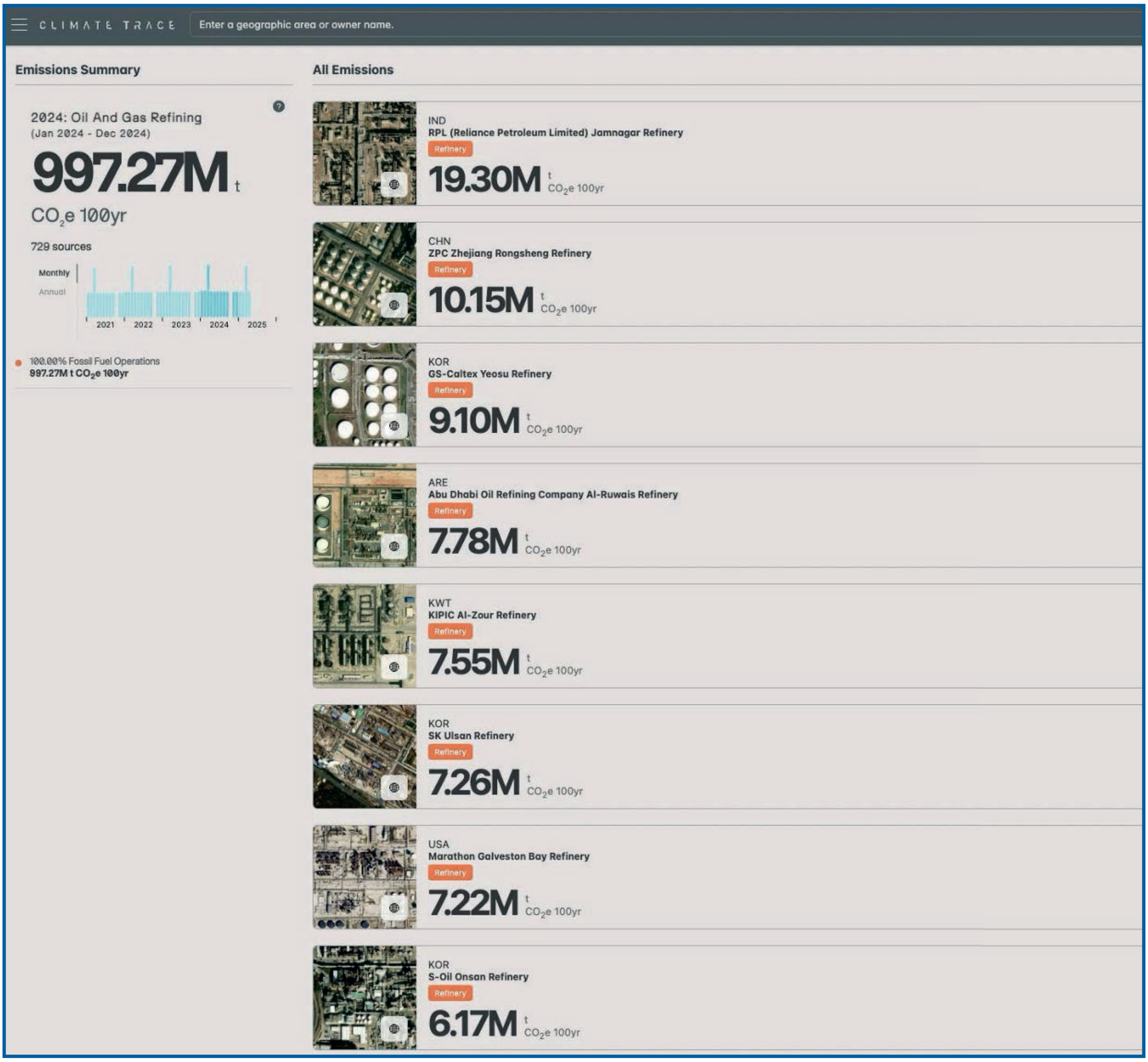


Figure 6: https://climatetrace.org/explore/#admin=&gas=co2e&year=2024&timeframe=100&sector=fossil-fuel-operations,oil-and-gas-refining&asset= Screenshot taken 10/08/2025

According to Sterling Thermal Technology, the eight largest active refineries in the world in 2025 are: (1)

1 Jamnagar Refinery, India - capacity 1,240,000 barrels of crude oil per day.

2 Paraguaná Refinery Complex, Venezuela - capacity 971,000 barrels per day.

3 SK Energy Ulsan Refinery Complex, South Korea - capacity 840,000 barrels per day.

4 Ruwais Refinery, Abu Dhabi - capacity 837,000 barrels per day.

5 Yeosu Refinery, South Korea - capacity 800,000 barrels per day.

6 Onsan Refinery, South Korea - capacity 669,000 barrels per day.

7 Port Arthur Refinery, Texas, USA - capacity 630,000 barrels per day.

8 Jurong Island Refinery, Singapore - capacity 630,000 barrels per day.

If we compare these two lists, Jamnagar aside, they don't match. This could be due to several factors, which could be easily ascertained by purchasing the relevant data.

The simplest and most obvious is that the refinery is not operating to capacity. The Energy Institute publishes data on annual oil refinery throughput. (2) In 2024, Venezuelan refinery throughput was 238,000 barrels per day on a capacity of 1.2 million, down from 1.1 million barrels in 1991 and 1992. As a result of the prevailing political situation, Venezuelan oil production has plummeted, and emissions have fallen as a consequence.

A second is the nature of the refinery itself."The Nelson Complexity Index (NCI) is a measure of the sophistication of an oil refinery, where more complex refineries are able to produce lighter, more heavily refined and valuable products from a barrel of oil. Refineries that are higher on the Nelson Complexity Index are valued higher relative to their peers because of their ability to handle lower quality crude oil or produce more value-added products. Due to their greater complexity, high NCI refineries are more costly to build and operate." (3)

Offshore Technology claims that, according to GlobalData, of the world's largest active refineries, Jamnagar I and II have the highest NCIs -—14 and 11.3, respectively. (4) These are both integrated coking refineries, so they combine oil refining and petrochemical production within a single facility. Furthermore, in its 2019 Annual Report, Reliance Industries claimed that recent investments, including the world's first-ever Refinery Off-Gas Cracker complex using off-gases from Jamnagar refineries as feedstock, had enabled the complex to increase its NCI to 21.1. (5)

(1) https://www.sterlingtt.com/2023/02/15/largest-oil-refineries/#:~:text=The%20Jamnagar%20refinery%20is%20a,largest%20refinery%20in%20the%20world.

(2) https://www.energyinst.org/statistical-review/resources-and-data-downloads

(3) https://www.investopedia.com/terms/n/nelson-index.asp

(4) https://www.offshore-technology.com/data-insights/global-top-ten-active-oil-refineries/

(5) https://web.archive.org/web/20191012062659/https://economictimes.indiatimes.com/industry/en ergy/oil-gas/reliances-refinery-complexity-index-rises-to-21-1/articleshow/70397204.cms

Here, it is important to remember that while such refineries may have higher total emissions, other things being equal, the more products a refinery can produce from a barrel of oil, the more products the environmental impact is spread over, and so the lower the purported impact of each. Xylenes account for over a third of the total annual capacity of the Jamnagar complex, followed by polypropylene, propylene, ethylene, and benzene, respectively ('others' constitute the remaining ≈13%). The complex also includes Reliance Industries Jamnagar Diethylene Glycol Plant, Reliance Industries Jamnagar Ethylbenzene Plant, Reliance Industries Jamnagar Ethylene Plant 2, Reliance Industries Jamnagar Ethylene Plant 3, and Reliance Industries Jamnagar Ethylene Vinyl Acetate (EVA) Plant (for which the capacity information is n.a.). A detailed profile of Jamnagar can be purchased from GlobalData for USD125. [1]

Fortunately for us, and at least for the time being, every year, 125 US refining facilities, with an average capacity of 150kbpd, report their emissions data to the US EPA. THUNDER SAID ENERGY compiles and analyzes this data to produce an annual report that can be purchased for USD800. [2] Their website generously offers several observations on US refinery carbon efficiency, which indicate the probable relationship between NCI and carbon emissions. Specifically, "The average US refinery emits 33kg of direct CO_2 per barrel of throughput, with a **10x range** running **from sub-10 kg/bbl to around 100 kg/bbl**.... The 33 kg/bbl average CO_2 intensity comprises 20 kg/bbl of stationary combustion, 8 kg/bbl of other refining processes, 3 kg/bbl of on-site hydrogen generation, 1 kg/bbl of cogeneration, and 0.2 kg/bbl associated with methane leaks....Refineries that are more complex, make cleaner fuels, make their own hydrogen (rather than buying merchant hydrogen), and also make petrochemicals are clearly going to have higher CO_2 intensities than simple topping refineries. **There is a 50% correlation between different refineries' CO_2 intensity (in kg/bbl) and their Nelson Complexity Index** (our bold)." [3]

These numbers are more shocking than most of us realize. Oil varies in density, but on average, a 42-gallon barrel will weigh 137 kilograms. A refinery emitting 33 kgs of CO_2 per barrel of throughput will have a waste factor of approximately 24%, all of which is simply released into the atmosphere. We are not oil or petrochemical engineers, and doubtless there are subtleties and complexities of which we are unaware. However, the US refineries with the highest and lowest carbon emissions —100 kg/bbl and ≈5 kg/bbl, respectively — both appear to be simple topping refineries, as their emissions are almost entirely stationary. (Topping Refineries just separate Crude Oil into Petroleum Gases and liquid fractions by atmospheric distillation. Their output primarily serves as feedstock for petrochemicals manufacture or the industrial fuels market.) [4]

This suggests that considerable emissions savings could be made if anyone cared enough to track polyester to its source. It is well beyond the scope of this paper to analyse the different types of refineries and the manifold ways in which they can minimise their emissions.
Our point is rather that there are major emission differences between refineries. Indeed, even water consumption will vary; Jamnagar, for example, uses desalinated seawater. [5]

For brands and their initiatives to suggest that there is no need to trace polyester because, regardless of the source, the impact will be the same, is true neither for raw material extraction nor refining.
As for the production of the polyester itself, polyester is a family of plastics. The three dominant materials are polycarbonate (PC), polyethylene terephthalate (PET), and polybutylene terephthalate (PBT). Most polyester is Polyethylene Terephthalate or PET, an aliphatic polyester obtained from the polycondensation reaction of the monomers obtained either by:
Esterification reaction between terephthalic acid and ethylene glycol, or trans-esterification reaction between ethylene glycol and dimethyl terephthalate. [6]

Not surprisingly, Reliance Industries produces polyester staple fiber and filament yarn. Indeed, Reliance claims, "We are one of the largest producers of polyester fiber and yarn in the world, with a capacity of 2.5 million tonnes per annum." [7] (This means that Reliance Industries alone produces nearly as much polyester fiber as the United States produces cotton.)

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[1] https://www.offshore-technology.com/marketdata/reliance-industries-jamnagar-complex-india/?utm_source=&utm_medium=20-105395&utm_campaign=&cf-view&cf-closed&cf-view&cf-closed
[2] https://thundersaidenergy.com/downloads/us-refiners-co2-cost-curve/
[3] https://thundersaidenergy.com/downloads/us-refiners-co2-cost-curve/
[4] https://epcmholdings.com/decarbonizing-the-crude-oil-refining-industry/#:~:text=Topping%20Refineries:,as%20feedstock%20for%20Petrochemicals%20manuf acture
[5] https://web.archive.org/web/20191012062659/https://economictimes.indiatimes.com/industry/en ergy/oil-gas/reliances-refinery-complexity-index-rises-to-21-1/articleshow/70397204.cms
[6] https://www.specialchem.com/plastics/guide/polyethylene-terephthalate-pet-plastic
[7] https://www.ril.com/businesses/petrochemicals/polyesters

If a brand is purchasing Indian polyester, there is a very good chance that it came from Reliance and that the feedstock came from the Jamnagar complex, and indeed, was likely produced with Russian oil. Specifically, in the first seven months of 2025, the Finnish Centre for Research on Energy and Clean Air estimates that the Jamnagar refinery imported 18.3 million tonnes of crude oil, worth $8.7bn, from Russia — a 64 percent year-on-year increase. (1) Data shows that Reliance was already obtaining a third of its crude oil from India in 2023. (2) In December 2024, "Russia's largest and most valuable state oil company, Rosneft, agreed to supply nearly 500,000 barrels of crude oil daily to India's Reliance Industries, which operates the world's largest refinery, marking the biggest India-Russia energy deal ever, valued at $13 billion per year at current prices." (3) This 10-year agreement (with an option to extend for another 10 years) will account for 0.5% of the global supply and will be paid for in Roubles. (4)

The net result is that, while in 2021, Russian crude made up only 3% of Jamnagar refinery's total crude imports. By 2025, this share averaged 50%. (5)

In other words, brands enjoying 'exclusive partnerships' with Reliance, like Bottega Veneta, Balenciaga, Hugo Boss, and Adidas, (6) are running a 50% risk of using Russian oil in violation of sanctions. Indeed, Rosneft, along with Lukoil, was explicitly targeted in US sanctions. (7) The EU has similarly and simultaneously pumped up its own response, targeting the shadow fleet, cryptocurrency payments, and banning Russian liquefied natural gas imports. (8) Allowing Russian oil and gas to continue to flow into the USA/EU in the form of petrochemicals, including PET and polyester, undermines these efforts.

Figure 7: Global Polyester Production 2024

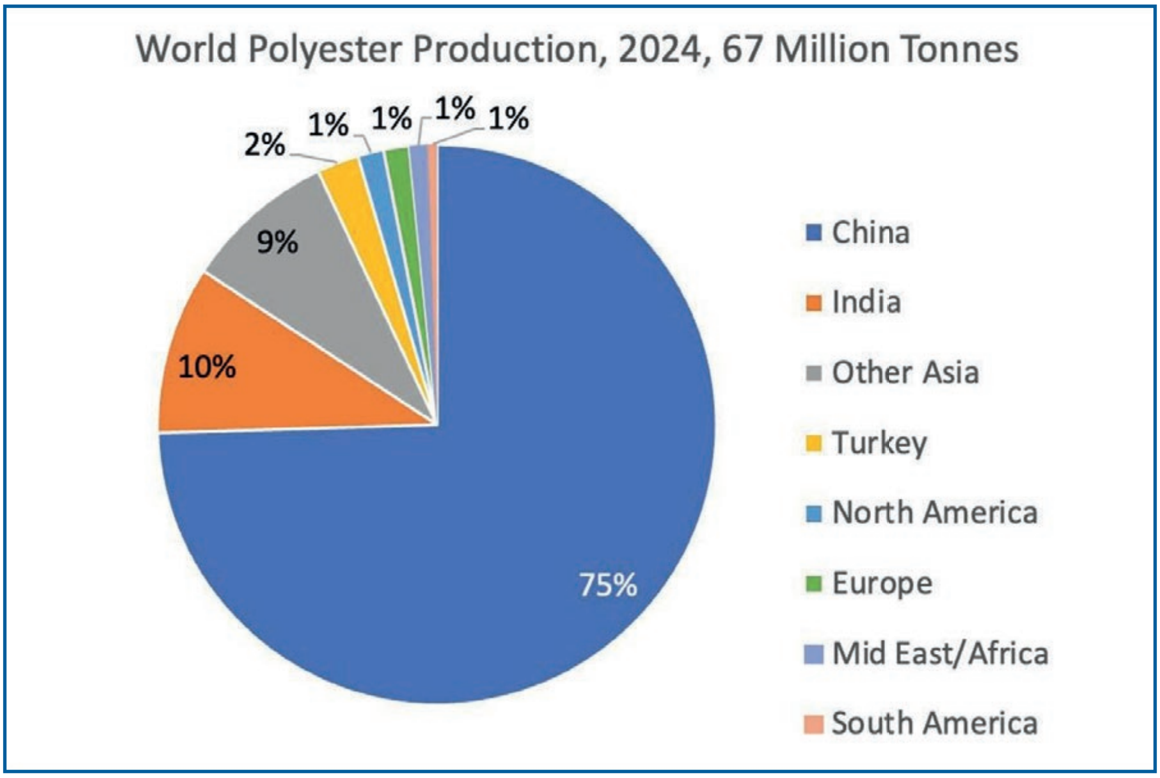

Figure 7: Wood Mackenzie

(1) https://www.aljazeera.com/economy/2025/8/22/behind-indias-massive-russian-oil-imports-asias-richest-man#:~:text=Russian%20crude%20comprised%20a%20mere,methodology%20can%20be%20f ound%20here

(2) https://www.livemint.com/market/commodities/europe-is-guzzling-diesel-from-india-a-key-buyer-of-russian-oil-11701101839421.html

(3) https://gfmag.com/capital-raising-corporate-finance/reliance-rosneft-russia-india-energy-alliance/#:~:text=As%20of%20July%202024%2C%20India,against%20Dubai%20quotes%20for%202025

(4) https://gfmag.com/capital-raising-corporate-finance/reliance-rosneft-russia-india-energy-alliance/#:~:text=As%20of%20July%202024%2C%20India,against%20Dubai%20quotes%20for%202025

(5) https://www.aljazeera.com/economy/2025/8/22/behind-indias-massive-russian-oil-imports-asias-richest-man

(6) https://www.ril.com/about/products-brands

(7) https://www.nytimes.com/2025/10/22/us/politics/trump-sanctions-russia-ukraine.html

(8) https://www.nytimes.com/2025/10/23/world/europe/eu-russia-sanctions.html

Sanctions aside, however, and returning to the point of this paper, namely fiber traceability, most polyester does not come from India. As Figure 7 shows, most polyester, 75% to be precise, comes from China. Indeed, while all eyes have been glued to cotton, some Chinese polyester is produced in Xinjiang. (1)

The other thing to note, and it is important to remember this when reading section 3, is that European polyester production represents just 1% of the global total, and Turkey, a member of Plastics Europe, represents a little over 2%. To assert that an LCA of European production (which didn't include any plants in Turkey) is representative of global output, is confounded by the facts, and is patently unscientific.

Moreover, China's largest producers dwarf Reliance. Chinese polyester manufacturers are expanding so rapidly that AI has difficulty keeping up. We provide further analysis in Appendix 1, but as shown in Table 7, Decon expected Tongkun to be the largest Chinese supplier in 2022, with a predicted capacity of 10.8 million tonnes. (2) As of August 2025, Tongkun Industries' website states that their polymerization capacity is 13 million tonnes and their polyester filament capacity is 13.5 million tonnes. (3) That's more than 5x Reliance Industries' polyester capacity (and approximately equal to half of world cotton production). Reliance polyester is indicative of Indian production, but not global output.

On the other hand, the fact that production is concentrated not just in China but also in a handful of major enterprises means that traceability and representative data collection would be relatively straightforward. Data on impacts for Tongkun alone would cover 27% of Chinese output and 20% of the global total. Where Tongkun obtains its petrochemicals from would not be difficult to ascertain. Indeed, Tongkun owns 20% of Zhejiang Petroleum & Chemical (ZPC) (4) reportedly, the largest construction and private enterprise in China. (5)

ZPC includes an 800,000-barrel-per-day refinery and a 4.2 million tonnes-per-annum ethylene cracker. As we can see from Figure 6, in 2024, ZPC Zhejiang Rongsheng Refinery had the second-highest emissions after Jamnagar. That remains the case in 2025. Aramco acquired a 10% interest in Rongsheng Petrochemical Co., Ltd, the principal owner of ZPC, in 2023. Aramco also signed a long-term crude oil supply agreement, providing 480,000 barrels per day of feedstock (60% of the refinery capacity) to ZPC. (6) This contract stipulates that the oil will come from Saudi Arabia. These kinds of contracts are not uncommon. It is not just Saudi Arabia that is betting on petrochemicals being the future of oil sales, and affluent NOCs (national oil companies) are investing in petrochemical plants around the world to lock in future markets. These contracts are tracked. As noted in section 2.e), GlobalData, for example, provides "Analysis on over 40,000 contracts, with more than 4,000 new contracts added each year." This naturally greatly simplifies traceability. In the absence of contracts, where Chinese refineries are obtaining their feedstock may also be readily ascertained from import data. As elaborated in Appendix 1, in 2023, Russia accounted for 15% of China's total oil supply. Iran accounted for 5%.

It is claimed that there is considerable overcapacity in Chinese polyester. Our analysis in Appendix 1 suggests this is correct. It has led to razor-thin margins, a cap on global prices, and traditional competitors shuttering plants. (7)

The European Union has recently been vocal in its criticism of "China's distortive policies which lead to industrial overcapacity". (8) The rise of PET capacity in China, however, appears to have been incentivised by an LCA-based perception that polyester is less environmentally harmful, or as the Berkshire Hathaway Group put it: " Advantageous properties of Polyester over cotton, substitute, act as one of the key factors driving the demand. Increasing popularity of sustainable man-made fibers coupled with reducing consumption of cotton in the textile industry is likely to drive the market over the forecast period." (9)

(1) https://www.chinaplasonline.com/eMarketplace/exhibitorinfo/eng?compid=1026571
(2) https://www.polyestermfg.com/top-10-polyester-manufacturers-in-china/#comments
(3) https://www.zjtkgf.com/en#:~:text=13%20million%20tons%20polymerization%20capacity,Innova tion%2C%20High%2Dprecision%20Manufacturing
(4) https://www.opensanctions.org/entities/NK-FDNb59QhFyR5vWe6u7JCK4/
(5) https://www.zjtkgf.com/en/industrial-layout
(6) https://www.whitecase.com/news/press-release/white-case-advises-aramco-acquisition-rongsheng-petrochemical
(7) https://www.bloominglobal.com/media/detail/global-polyester-giants-like-sk-group-and-lotte-chemical-scale-back-production
(8) https://lnkd.in/eAxJrk83
(9) https://www.businesswire.com/news/home/20200604005535/en/Global-Polyester-Market-Value-Volume-Assessment-2020-2025---ResearchAndMarkets.com

This notion of comparative sustainability has been actively promoted in Europe. For example, the "Global Fashion Agenda & Boston Consulting Group (2017) Pulse of the Fashion Industry recommended that the fashion industry replace "30% of 2030 cotton with polyester". (Page 72). [1] This report was cited as recently as December 2024 by the UN agency for desertification (UNCCD). [2] Moreover, the Copenhagen-based GFA has been supported at the highest political levels in Denmark for the past 15 years. [3] Indeed, as we will see in Section 3, the EU green policy's foundation stone for apparel and footwear - the PEF - favours polyester as less environmentally harmful than natural alternatives.

In other words, the EU's 'green' legislative package would appear to be contributing to the expansion of China's polyester production capacity.

F) CLIMATE CHANGE IMPACT OF COTTON CULTIVATION

The previous section notes the complexities involved in attempting to estimate climate emissions in oil and gas production and refining. All of these problems also apply to cotton (along with all wools and silk) and more so. Not only is it difficult to ascertain the impact of methane, for example, on climate change. In farming, it is equally hard to estimate the net amount of methane being emitted, even when the farm is known and able to provide all available data. This has caused considerable problems for the use of manure in organic cotton production. Based on standard LCA conversion, manure shows a prohibitive climate impact.

Various initiatives and LCA providers have attempted to get around this by either:

a) incorrectly claiming, for organic cotton and organic cotton alone, that manure is free waste from another system and excluding it from the impact calculations.
Or

b) as recently happened in California, by refusing to include organic farms in the final publication.

In our opinion, these are the wrong approaches. If LCAs do not capture the benefits of organic cultivation, only the costs, the solution is not to bend the rules for organic alone and carry on pretending that LCAs capture the impacts of conventional production systems. The solution is to closely examine how emissions and other impacts are being calculated in an agricultural context. Are important considerations excluded? We cite the Chair of the Technical Secretariat EU PEF for Apparel and Footwear (A&F), someone well aware of the intricacies of LCAs, speaking at Natural fiber Connect in 2024:
"on my Farms, we started to develop a new way of growing wine instead of having a full Vineyard, we do 10 rows of Vineyard one hedge with big trees 10 R of Vineyard one hedge from an LCA perspective that's a disaster. Lowering my yield per surface hence the footprint of what I provide is higher and the benefit of my hedge biodiversity and other elements are not measured so I'm doing something out of conviction". [4]

LCAs were not created with agricultural production in mind, and LCA providers do not know the intricacies of modern farming. As we pointed out in a previous paper [5] the first ever published LCA was a cradle-to-gate assessment conducted by Coca-Cola in 1969. LCA providers have since convinced us that LCAs can measure all types of fiber production and tell us everything we need to know. We question this.

[1] https://www2.globalfashionagenda.com/wp-content/uploads/2017/05/Pulse-of-the-Fashion-Industry_2017.pdf
[2] https://baumwollboerse.de/en/competencies/publications/report-on-un/
[3] https://globalfashionagenda.org/news-article/hm-queen-mary-fifteen-years-of-supporting-sustainable-fashion-2/
[4] https://www.youtube.com/watch?v=LshDE1bHNM8
[5] https://baumwollboerse.de/en/competencies/publications/report-on-un/

It might be helpful if all farmed fiber producers, both organic and conventional, united and shared data and experiences to evaluate the contentions of LCA providers and, indeed, global regulators (see section 3). Are the emissions claimed for agriculture accurate and representative of the complete picture, or are they, as Anil Agarwal put it in 1991, "politically motivated and mathematical jugglery. Its main intention seems to be to blame developing countries for global warming and perpetuate the current global inequality in the use of the Earth's environment and its resources." [1]

Indeed, it's not just developing countries' agriculture that is being blamed. It's all agriculture everywhere. LCA providers, sustainability experts, and regulators claim to be guided by science, but as we just saw in the previous section, science advances. Improved modeling on lifecycle emissions and data sources led Climate Trace to change total and relative emissions for oil and gas extraction considerably in July 2025, and to change them again in December, and slightly again by March 2026. Farms are not oil and gas wells. Tracing and measuring emissions is far more complex. To quote an expert: "Some of the biggest emission sources are influenced by a range of farm-specific conditions and are therefore more challenging to calculate. For example, when applying nitrogen fertiliser to a field, we get nitrous oxide emissions, and those emissions are not only influenced by the quantity of nitrogen applied but also by factors like management practices, **soil properties, and weather conditions."** [2] [our bold]

In May 2023, at a cost of UK£100,000, DEFRA, the UK Department for Environment, Food & Rural Affairs, analysed the functionality of six carbon calculators in farm-level carbon assessments. [3] The study created 20 model farms, with two of each of the nine Defra farm types, and applied 6 different tools: Agrecalc Ltd's Agrecalc, The Cool Farm Alliance's Cool Farm Tool, Eggbase Ltd's carbon footprint tool, Farm Carbon Toolkit's Farm Carbon Calculator, Trinity AgTech's Natural Capital Navigator Sandy, and Solagro's The Farm Carbon Calculator.

As of 2024, there were over 80 carbon tools for quantifying farm emissions in existence. [4]

As DEFRA observed:
"There are differences in how calculators account for enteric emissions, nitrous oxide emissions from fertiliser application, crop residues, and manure management. Land-based carbon removals and emissions: There is currently no consistent approach taken to assessing carbon removals or emissions from soils, vegetation, and land use change by calculators." [5] Not surprisingly, different calculators come up with very different emissions. The outcome for the DEFRA study is shown in the chart in Table 6.

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1. https://baumwollboerse.de/en/competencies/publications/report-on-un/
2. https://adas.co.uk/news/harmonisation-of-carbon-accounting-tools-for-agriculture-report-published/
3. https://sciencesearch.defra.gov.uk/ProjectDetails?ProjectId=20967
4. https://adas.co.uk/news/harmonisation-of-carbon-accounting-tools-for-agriculture-report-published/
5. https://sciencesearch.defra.gov.uk/ProjectDetails?ProjectId=20967

Table 6: Purported Carbon Emissions for 20 Model Farms Using the 6 Most Common Calculator Tools in the UK in 2023

Table 1. Statistics on the farm-level emissions of the 20 model farms. Emissions of max. relative to min. shows the emissions of the calculator with the highest emissions relative to the emissions of the calculator with the lowest emissions (a result of 100% means they give the same emissions). Bold text shows model farms where the maximum emissions were more than twice as high as the minimum emissions. Italic text shows model farms where maximum emissions are less than 150% of the minimum emissions Three model farms also have results that include carbon stock changes (noted by 'w/C stock change'). Here, emissions refer to net emissions where carbon stock changes are included.

Model farm	No. of results	Min. farm emissions (t CO_2e/farm)	Max. farm emissions (t CO_2e/farm)	Mean farm emissions (t CO_2e/farm)	Emissions of max. relative to min.
Cereals 1	5	1,187	2,080	1,636	175%
w/C stock change	5	1,015	2,233	1,661	**220%**
Cereals 2	4	742	949	820	*128%*
Gen. crop. 1	5	281	480	336	171%
w/C stock change	5	297	3,242	1,245	**1,093%**
Gen. crop. 2	4	4	5	4	*129%*
Horticulture 1	3	133	210	174	157%
Horticulture 2	3	1,112	2,650	1,994	**238%**
Pigs 1	4	598	798	716	*133%*
Pigs 2	4	1,539	3,844	2,758	**250%**
Poultry 1	6	78	278	160	**355%**
Poultry 2	5	895	4,014	1,863	**448%**
Dairy 1	5	5,102	6,571	6,022	*129%*
w/C stock change	5	5,132	7,974	6,095	155%
Dairy 2	4	1,442	1,772	1,611	*123%*
Dairy 3	4	4,143	5,858	5,318	*141%*
Dairy 4	4	1,562	2,240	1,862	*143%*
LFA grazing 1	4	2,096	4,115	2,716	196%
LFA grazing 2	4	253	276	268	*109%*
Lowland 1	4	354	996	553	**281%**
Lowland 2	4	141	335	204	**238%**
Mixed 1	4	553	993	755	179%
Mixed 2	4	536	1,164	836	**217%**

Table 6: https://sciencesearch.defra.gov.uk/ProjectDetails?ProjectId=20967

As we can see, even with a mere 20 farm types, just within the UK, and only using 6 different tools, there are major differences in the outcomes.

A further complexity is how to address the fundamental difference between natural fibers, such as cotton, which are composed of carbon recycled from the air or soil, and synthetic fibers such as polyester, where the carbon constituents are obtained through mining of ancient geological carbon stocks, which are then released into the contemporary environment. The accurate capture of biogenic carbon is beyond most LCAs. Work is underway to address this, and early results suggest a significant reduction in purported carbon emissions for agricultural products. A 2025 preprint study of the Carbon Intensity of Wool Production showed reductions in wool CO_2e emissions intensity of 96%. [1]
Similarly, a former Executive Director of the European Environment Agency recently published a preprint study of Soil Carbon Sequestration (SCS), which suggested that: "Soil carbon farming has the potential to bridge the global emissions gap." This analysis calculated that increasing the average soil organic carbon in cropland and pasture by 1 per cent globally could lead to carbon sequestration of 311 $GtCO_2e$ or the equivalent of the 2030 emissions reduction gap. [2] Indeed, France launched the International "4 per 1000" Initiative in 2015 to show that agriculture, and in particular agricultural soils, can play a crucial role in combating climate change. The program aims to increase soil organic matter by 0.4% annually to this end. [3] The European Commission is a member. [4] One of the principal recommendations is that policy measures must be established to encourage ecological farming practices that meet the 4 parts per thousand objective. The use of cover crops and manure is specifically mentioned as beneficial. [5]

Bafflingly, this is not included in the French PEF [6] and so far, has not been included in the EU PEF either. Even more perplexing, perhaps, is the claim that the French ADEME (see Appendix 2 for further details) database includes "The environmental benefits of practicing sustainable agriculture." [7] As Appendix 2 demonstrates, that is far from the case. When LCAs are used for their original purpose, to identify hotspots in the production system, this doesn't matter as much. Or as DEFRA puts it, " Despite the areas of divergence identified, the calculators are all able to provide the farmer with a robust baseline understanding of emissions and can facilitate the start, and ongoing development, of a decarbonisation process." [8]

The problem arises when these values are interpreted by well-intentioned regulators as representing scientifically grounded, impartial frameworks enabling consistent comparative measurement. Or, as one 2025 study puts it: "The [ISO]14040–14049 series of standards function as guidelines. They are principle-based and not prescriptive in relation to choice of environmental impact category..... This makes the application of LCAs highly dependent on practitioner choices and the adequacy and appropriateness of data. As a rapidly evolving field of science, LCA is therefore exposed to the risk of paradigm confirmation biases – risks partly contained while LCA remained primarily a company-based attributional tool.....However, with the increasing reliance of policymakers upon LCAs the risk is heightened." [9]

The EU PEF, for example, specifically excludes soil carbon storage (SCS). "Soil carbon uptake (accumulation) shall be excluded from the results, e.g., from grasslands or improved land management through tilling techniques or other management measures taken related to agricultural land. Soil carbon storage may only be included in the PEF study as additional environmental information." [10] Given the EU promotion of organic and regenerative agricultural programs that seek to promote SCS and the potential for climate change mitigation that SCS represents, this is counterproductive. That said, methods of biogenic carbon removal in the Product Environmental Footprint (PEF) are currently being debated within the Technical Advisory Board (TAB), but at this stage, it appears these will apply only to organic cultivation.

1. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5165930&maincontent
2. https://ucl.scienceopen.com/document/read?vid=fb1b48e4-0868-47f8-b7cc-8cfe8c89ca12#comment_b4f7eb01-2656-4ea2-b4e4-0fa6bb3c4ee3
3. https://4p1000.org/discover/?lang=en
4. https://4p1000.org/wp-content/uploads/updated_partners_members.pdf
5. https://4p1000.org/?lang=en
6. https://technical-regulation-information-system.ec.europa.eu/fr/notification/26667
7. https://worldly.io/resources/introduction-to-environmental-labeling-and-french-eco-score-what-brands-manufacturers-and-retailers-need-to-know/
8. https://sciencesearch.defra.gov.uk/ProjectDetails?ProjectId=20967
9. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5165930
10. https://environment.ec.europa.eu/publications/recommendation-use-environmental-footprint-methods_en

Science advances, and accuracy requires that we listen. Currently, however, as shown in Section 3 and Appendix 2, based on LCAs that exclude these vital system services, and/or which are outdated and unrepresentative, highly improbable values are commonly cited as representing emissions in both cotton cultivation and PET production. The pretence that numbers constitute valid science simply because they came from an LCA, no matter how superannuated and unrepresentative the data concerned, is nefarious and highly misleading.

This would appear to be an excellent opportunity for the farmed fiber community — conventional, organic, regenerative, crop and livestock -— to unite and collaborate on a detailed evaluation of this complex issue. Here, we aim only to illustrate that when we discuss carbon emissions in cotton production, we are discussing something imprecise, potentially, if not probably inaccurate, and from which significant benefits are excluded.

From their response to the RoR (see Annex 2), it would appear that TE does not disagree with our assessment, asserting both that "We have consistently stated that the impact of fibers from different production systems, particularly synthetic vs. natural systems, **should not be compared**." And that their LCA+ approach considers impacts holistically, and we quote:"[TE] support the continued development of **impact assessment methodologies that capture a full range of impacts**, including biodiversity, soil health, and livelihoods, while also supporting viable transition pathways for farmers."

Yet we can find no record of TE expressing these convictions to either the French or EU agencies responsible for the respective nations' PEF and associated green legislation. On the contrary, what documentation there is [1] suggests that TE, particularly through its association with the Policy Hub [2] is broadly supportive of both countries' use of narrow LCA assessment methodologies to develop regulations that compare the impact of fibers from synthetic vs. natural systems. We would argue that if TE is not supportive of narrow LCAs and comparative fiber assertions, it must make this clear to regulators. It cannot ask farmers to adopt and adhere to systems that legislation does not recognise.

G) BIODIVERSITY IMPACT OF FIBER PRODUCTION

This paper does not attempt to evaluate the comparative biodiversity impacts of cotton and polyester production, as the topic is extensive and poorly documented. For context, we note that a December 2025 publication by Pew states that the cost of plastic pollution on marine ecosystems has been estimated at between US$500 billion and US$2.5 trillion (2019 values) annually. [3]

Furthermore, biodiversity is not currently one of the metrics included in either PEF or in the Higg MSI. Along with methods of biogenic carbon removal, methods to measure biodiversity are currently being debated within the PEF Technical Advisory Board (TAB), but again, they currently only appear to apply to organic cultivation. [4]

For now, it suffices to say that production of both cotton and polyester will have biodiversity impacts. But from oil spills to the influence of microplastics on plants and organisms, [5] it is hard to believe that cotton's negative biodiversity impact matches that of polyester. As just one example, the 2022 compendium study of US fracking impacts notes that "spills and intentional discharges into surface water have profoundly altered the chemistry and ecology of streams throughout entire watersheds, increasing downstream levels of radioactive elements, heavy metals, endocrine disruptors, toxic disinfection byproducts, and acidity, and decreasing aquatic biodiversity." [6]

1. https://textileexchange.org/eu-sustainability-policy-impacts-on-industry-and-standards/
2. https://www.policyhub.org/positions#:~:text=EPR%20For%20Textiles&text=The%20Policy%20Hub's%20mission%20is,Textile%20Strategy%20impactful%20and%20efficient
3. https://www.pew.org/en/research-and-analysis/reports/2025/12/breaking-the-plastic-wave-2025
4. NB. One of the authors of this report was a member of the TAB in 2025. The assessment and opinions offered in this report should not be interpreted as representing those of Euratex or any of its members.
5. https://baumwollboerse.de/en/competencies/publications/report-on-un/
6. https://psr.org/wp-content/uploads/2022/04/compendium-8.pdf

The combined footprint of just one well pad in unconventional natural gas development can total more than 12 ha (30 acres) and may involve deforestation. (1) As of 2022, there were already 1 million such wells across the USA, and the number has certainly increased since. (2)

In other words, the land use footprint of US oil and gas alone is likely over 12 million hectares.

By comparison, the world cotton area has ranged between 30 and 35 million hectares since WWII. (3)

We have not even touched upon the biodiversity impact of more traditional extraction and transportation. Oil and gas pipelines, thousands of kilometers long, criss-cross the globe with concomitant concerns over the sensitive terrain and the increased risk of oil spills. (4) For the year 2024, six large spills (>700 tonnes) and four medium spills (7-700 tonnes) were recorded from tanker incidents. In 2025, the numbers were 3 and 3, respectively, bringing the decade average to date to 7 spills per year. The average for the 2010s was 6 per year. (5) Spills also occur in seepage from poorly maintained facilities, tank farms, and in onshore and offshore drilling. Deepwater Horizon, for example, leaked roughly 4 million barrels in 2010, of which only 810,000 were captured. (6) The list goes on, and there is doubtless a lot more to uncover. If brands and their funded initiatives care as much about biodiversity as they all currently claim, the logical outcome would be to trace polyester, find out where the feedstock is coming from, and evaluate harmful impacts — including biodiversity impacts.

3. STRUCTURAL CAUSES OF DISTORTION IN SUSTAINABILITY ASSESSMENT TOOLS

The net result of the lack of industry and, indeed, legislators' interest in tracing and so understanding virgin polyester sourcing manifests itself in an absence of data on that fiber's raw material impacts.

To demonstrate this, we examine the European Union's Product Environmental Footprint, or PEF, the French PEF, and the Cascale/Worldly Higg MSI.

There is, surprisingly, and certainly regrettably, no single EU website offering insights into the mechanics and current impacts of the proposed PEF for Apparel and Footwear. Based on the final report on a potential framework for the environmental footprint database, published in 2025, (7) access to the all-important database, which determines whether the PEF is a valid metric or GIGO (garbage in, garbage out), is intended to remain tightly controlled. Figure 29 in Appendix 3 is a screenshot from that report. As we can see, access to the database is, and is intended to remain, restricted to LCA providers. Indeed, that final framework report was produced by an LCA provider - PRé Sustainability (see below for further details). In other words, select LCA providers will determine what data is used to represent industries and commercial activities of which they have no expert knowledge. (8)

And there will be no oversight.

(1) https://www.sciencedirect.com/science/article/pii/S1470160X14005664
(2) https://psr.org/wp-content/uploads/2022/04/compendium-8.pdf
(3) https://www.crdc.com.au/sites/default/files/pdf/ESPR%20critique.pdf
(4) https://www.offshore-technology.com/features/worlds-longest-pipelines/?cf-view
(5) https://www.itopf.org/knowledge-resources/data-statistics/oil-tanker-spill-statistics-2024/
(6) https://www.science.org/content/article/after-geoscientists-joust-judge-rules-bp-gulf-spill-totaled-319-million-barrels-oil#:~:text=After%20a%20lengthy%20court%20proceeding,None%20 of%20these%20were%20 perfect.%22
(7) https://op.europa.eu/en/publication-detail/-/publication/68e375bd-de4d-11ef-be2a-01aa75ed71a1
(8) https://gcbhr.org/backoffice/resources/the-rise-of-lcas-and-the-fall-of-sustainability.pdf

The best open-access alternative that we have found is a website by a private provider, Glimpact (Glimpact was offered an RoR to this paper, but did not respond) (1) Glimpact offers an App to enable brands to "Calculate the overall environmental impact of your textile products according to the PEF method adopted by the European Union for the new Eco-design for Sustainable Products Regulation* (ESPR).* according to PEFCR Apparel & Footwear 2.0 using EF 3.1 database." (2)

As we can see from the following screenshots from the Glimpact website, the PEF EF3.1 database includes 17 different LCAs for cotton. Cotton constitutes c21% of the global fiber supply. Indeed, the PEF database includes 6 LCAs for organic cotton, and according to the ICAC, organic production constituted only 1.4% of global cotton in 2020/21, and it is unlikely that the proportion has grown, so a mere 0.003% of the total global fiber supply. (3)

Figure 8: Glimpact — LCA Data Sources for Cotton

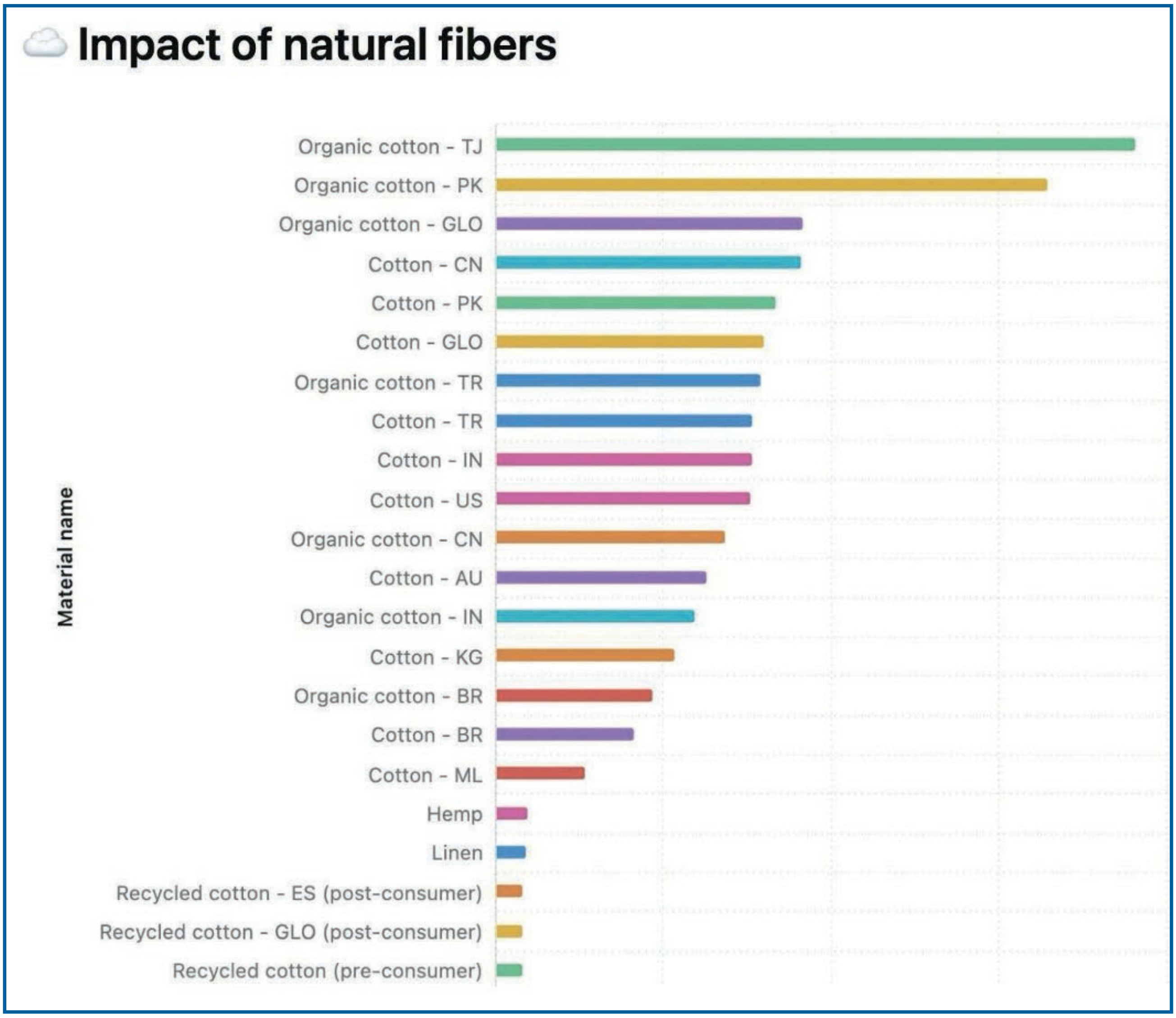


Figure 8: https://doc.glimpact.com/Impact-of-materials-12e653535d7d81fca91ffd34d6caadea Screenshot taken June 2025

The PEF database includes 6 different LCA studies covering various types of wool. Wool constitutes 0.8% (less than one percent) of the global fiber supply as of 2025.

(1) https://www.glimpact.com/glimpact-apps
(2) https://www.glimpact.com/global-impact-score
(3) https://icacdatabook.de.r.appspot.com/

Figure 9: Glimpact — LCA Data Sources for Wool

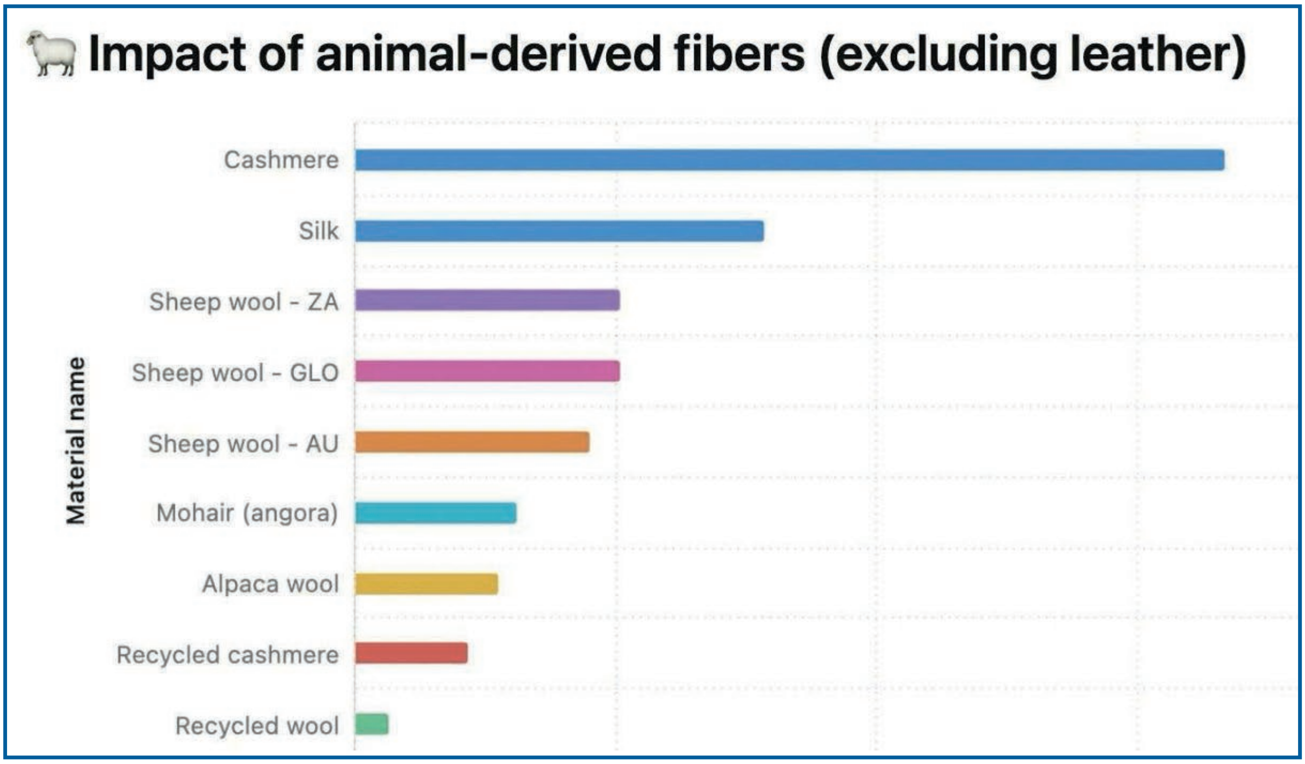


Figure 9: https://doc.glimpact.com/Impact-of-materials-12e653535d7d81fca91ffd34d6caadea Screenshot taken June 2025

But the PEF only includes a single LCA for virgin polyester PET. Polyester constituted c56% of the global fiber supply in 2024; of that, only about 12% is recycled, predominantly (98%) from plastic bottles.[1]

Figure 10: Glimpact — Raw Material Plastic fibers on the next page >>

[1] https://2d73cea0.delivery.rocketcdn.me/app/uploads/2025/09/Materials-Market-Report-2025.pdf

Figure 10: Glimpact — Raw Material Plastic fibers

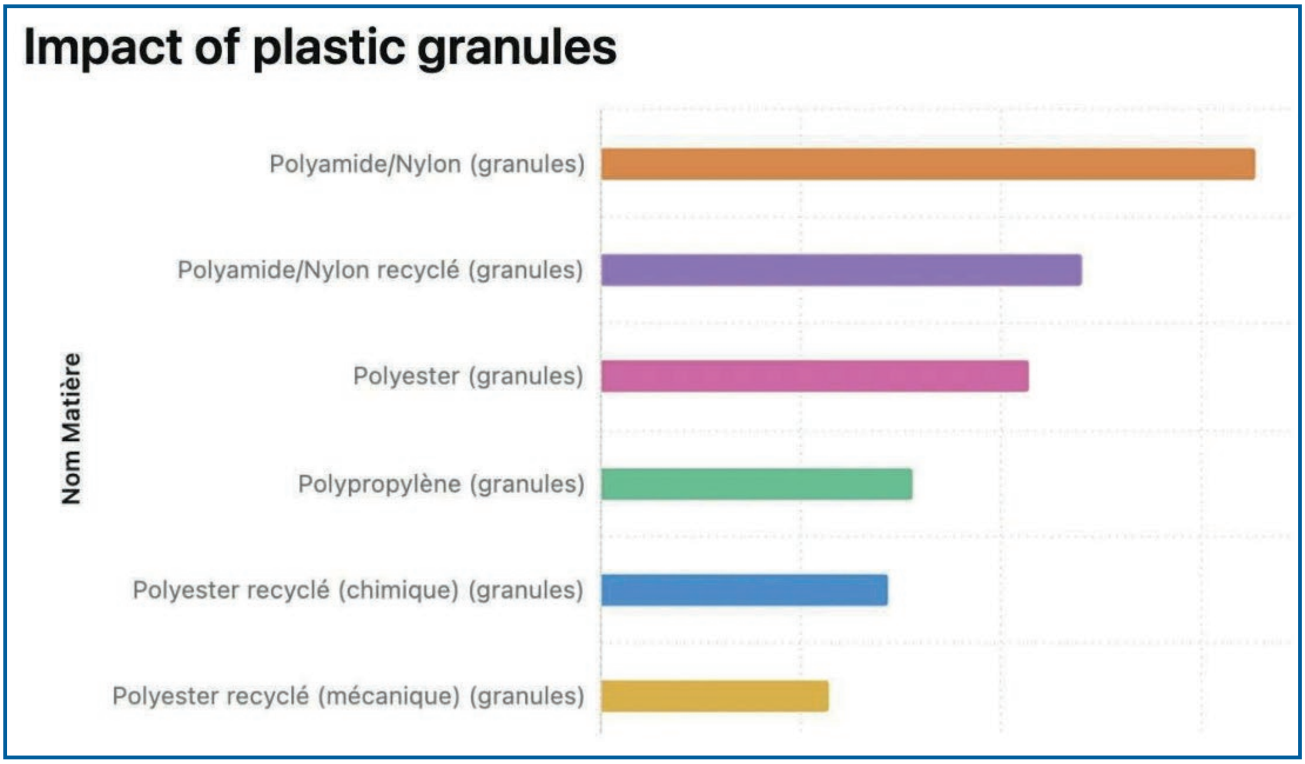


Figure 10: https://doc.glimpact.com/Impact-of-materials-12e653535d7d81fca91ffd34d6caadea Screenshot taken June 2025

A single LCA to represent half the world's total fiber supply. That is extraordinary! Furthermore, to the best of our knowledge, and as we have just pointed out, concerned citizens cannot simply check this, the single LCA that the EU PEF and the French PEF are all using (and that the Higg MSI used up until March 1, 2026), covers European polyester production, and European production alone. Specifically, as Figure 11 shows, the French PEF is based on Ecoinvent.

Figure 11: Ecobalyse Data Source for the Production of Virgin PET Polyester (Screenshot) 10/06/2025

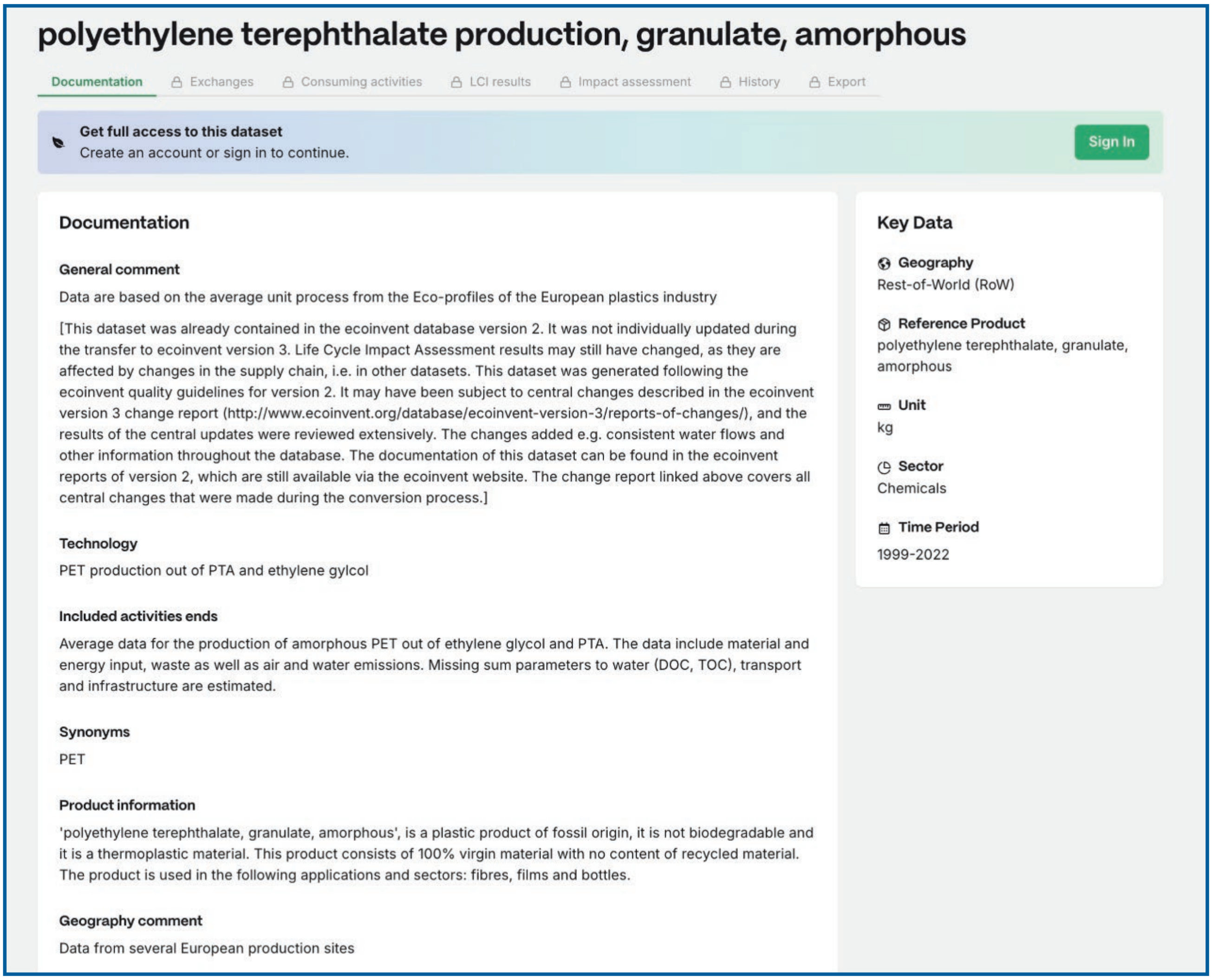
Polyester

Procédé Ecoinvent => *polyethylene terephthalate production, granulate, amorphous*

Figure 11: https://fabrique-numerique.gitbook.io/ecobalyse/textile/cycle-de-vie-des-produits-textiles/etape-1-matieres/focus-polyester screenshot taken 10/06/2025

The Ecoinvent site, however, despite claiming 3 datasets for polyethylene terephthalate production, granulate, amorphous - Average data for the production of amorphous PET out of ethylene glycol and PTA: Rest-of-World, Europe (RER), and Canada, as illustrated in Figure 12, offers the same "Geography comment" on all 3: "Data from several European production sites". In other words, the base data for all 3 geographies is the same. It's for European production.

Figure 12: Ecoinvent PET Production Dataset (Screenshot, 23/03/2026)



polyethylene terephthalate production, granulate, amorphous

Documentation | Exchanges | Consuming activities | LCI results | Impact assessment | History | Export

Get full access to this dataset
Create an account or sign in to continue.

Sign In

Documentation

General comment

Data are based on the average unit process from the Eco-profiles of the European plastics industry

[This dataset was already contained in the ecoinvent database version 2. It was not individually updated during the transfer to ecoinvent version 3. Life Cycle Impact Assessment results may still have changed, as they are affected by changes in the supply chain, i.e. in other datasets. This dataset was generated following the ecoinvent quality guidelines for version 2. It may have been subject to central changes described in the ecoinvent version 3 change report (http://www.ecoinvent.org/database/ecoinvent-version-3/reports-of-changes/), and the results of the central updates were reviewed extensively. The changes added e.g. consistent water flows and other information throughout the database. The documentation of this dataset can be found in the ecoinvent reports of version 2, which are still available via the ecoinvent website. The change report linked above covers all central changes that were made during the conversion process.]

Technology

PET production out of PTA and ethylene gylcol

Included activities ends

Average data for the production of amorphous PET out of ethylene glycol and PTA. The data include material and energy input, waste as well as air and water emissions. Missing sum parameters to water (DOC, TOC), transport and infrastructure are estimated.

Synonyms

PET

Product information

'polyethylene terephthalate, granulate, amorphous', is a plastic product of fossil origin, it is not biodegradable and it is a thermoplastic material. This product consists of 100% virgin material with no content of recycled material. The product is used in the following applications and sectors: fibres, films and bottles.

Geography comment

Data from several European production sites

Key Data

Geography
Rest-of-World (RoW)

Reference Product
polyethylene terephthalate, granulate, amorphous

Unit
kg

Sector
Chemicals

Time Period
1999-2022

Figure 12: https://ecoquery.ecoinvent.org/3.9.1/cutoff/dataset/4849/documentation Screenshot taken 23/06/2025

Given that, as shown in Figure 10, the Glimpact website indicates that there is only one LCA for polyester granules, and, given that Plastics Europe explicitly states that their Eco-profile datasets can be found as a source starting from version 3.6 of the EcoInvent database, [1] it appears all but certain that the polyester LCA that all of these tools are using is from Plastics Europe. [2]

Looking at the data available on PET production on the Plastics Europe website, the screenshots taken in June 2025, shown in Figures 13 and 14, clearly indicate that the data is superannuated. The data for the production process is from 2009. The data for the feedstock is from 2001. Readers who have been following this report closely and recall the rising emissions and changing trade flows in global oil and gas production discussed in sections 2.a), c), and e) will realize that this must seriously understate the current emissions, water consumption, toxicity, and land use impacts of oil and gas extraction, and so, of polyester.

[1] https://plasticseurope.org/sustainability/circularity/life-cycle-thinking/eco-profiles-set/

[2] The 2017 Committee of PET Manufacturers in Europe. Eco Profile of bottle grade PET states that the following companies contributed data: Equipolymers GmbH, Germany; Indorama Ventures Quimica S.L.U., Spain; Indorama Ventures Europe B.V., The Netherlands; Indorama Ventures Poland Sp. z o.o., Poland; JBF Global Europe BVBA, Belgium; Lotte Chemical UK Ltd, United Kingdom; NOVAPET S.A., Spain; Plastiverd, Pet Reciclado S.A., Spain; UAB "NEO GROUP", Lithuania; UAB Orion Global Pet, Lithuania https://plasticseurope.org/sustainability/circularity/life-cycle-thinking/eco-profiles-set/

Figure 13: Plastics Europe — Bottle Grade PET, Process Date 2009 (Screenshot, 2025)

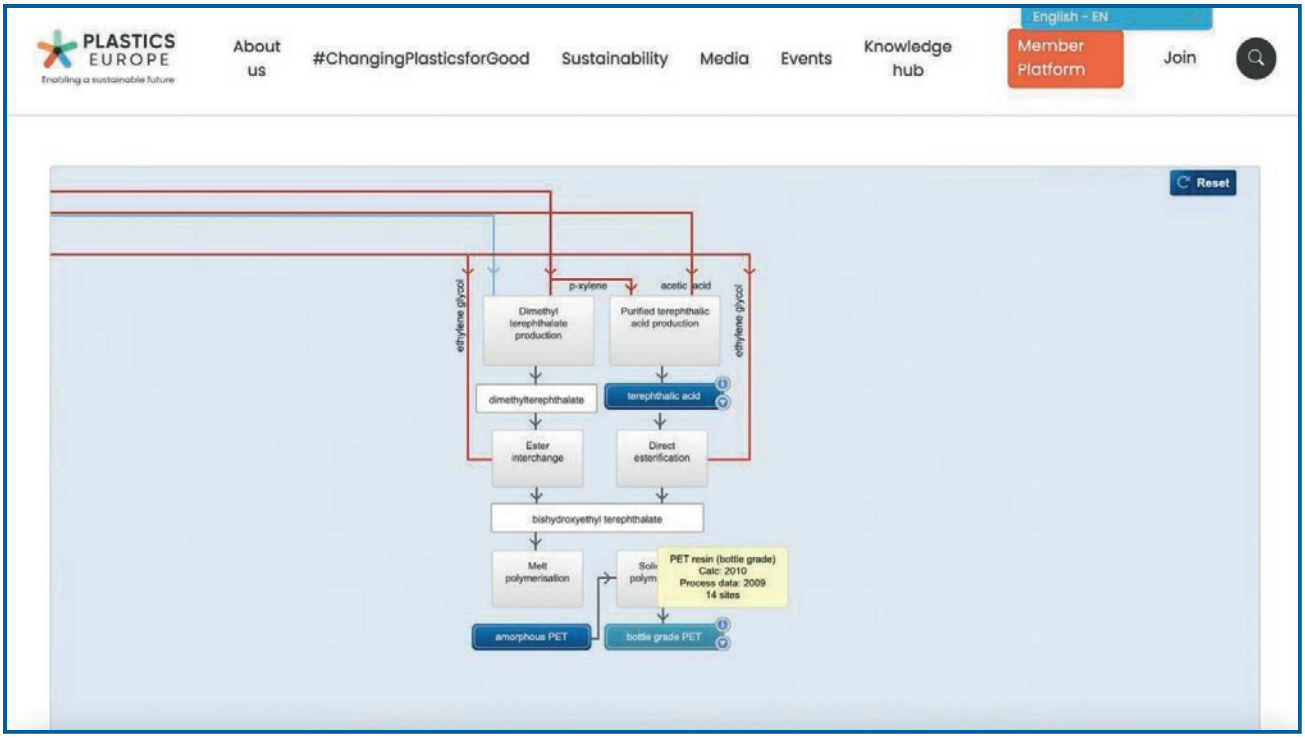


Figure 13: https://plasticseurope.org/sustainability/circularity/life-cycle-thinking/eco-profiles-set/ Screenshot taken 24/06/2025

Figure 14: Plastics Europe — Underlying Feedstock: Crude Oil and Natural Gas, Process Date 2001 on the next page >>

Figure 14: Plastics Europe — Underlying Feedstock: Crude Oil and Natural Gas, Process Date 2001 (Screenshot, 2025)

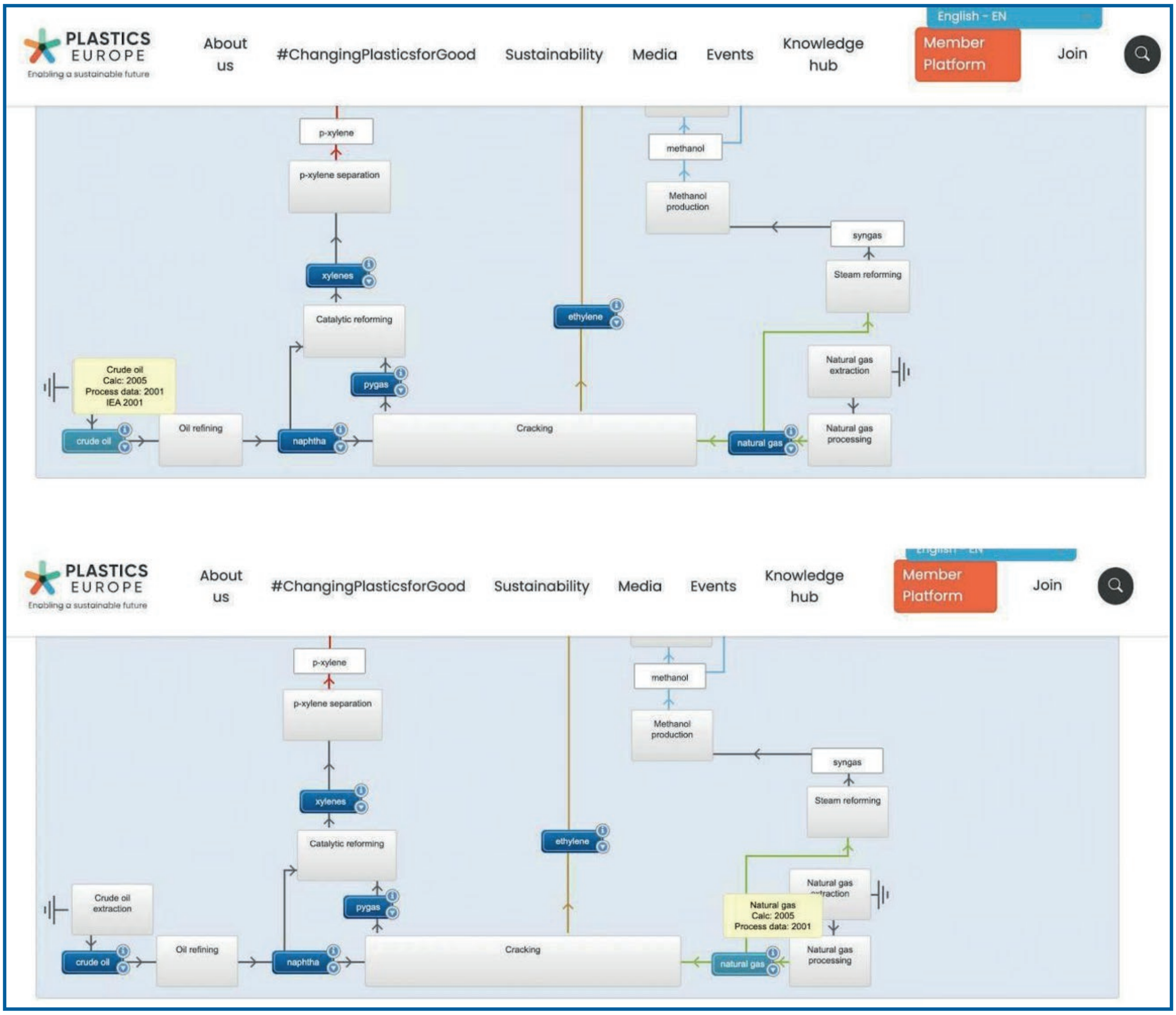


Figure 14: https://plasticseurope.org/sustainability/circularity/life-cycle-thinking/eco-profiles-set/ Screenshot taken 23/06/2025

As shown in Figure 30 in Appendix 3, the Worldly Higg MSI, on the other hand, claims to get its data from the Sphera database. Closer examination of that, however, reveals that yet again the data is unique to Europe. We quote:" the data set represents the country specific situation in Europe, focusing on the main technologies, the region specific characteristics and / or import statistics." (1) Plastics Europe specifically states that their eco profiles can be found in the Sphera GaBi database. (2)

Plastics Europe is well aware that its feedstock values are no longer valid. We quote:
"A number of publications report an increase of CO_2 emissions from flaring and an increase of methane emissions allocated to Oil and Gas production….Current Polyolefins eco-profiles datasets keep a good production process representativeness but need now to be aligned with main LCI databases regarding Oil and Gas datasets, inducing an increase of the Carbon Footprint of polymers.

(1) https://lcadatabase.sphera.com/2024/xml-data/processes/4b2420b3-8f56-45f1-984d-173a9298ef4a.xml
(2) https://plasticseurope.org/sustainability/circularity/life-cycle-thinking/eco-profiles-set/

This increase is the result of improved scientific detection methods for GHG emissions, particularly from satellites, resulting in increased emissions from Oil & Gas production that were not accounted for in the past. It is important to note, the increase reported does not arise from an increase in actual emissions due to either downgrading practices or recent shale gas exploitation." Our bold (1)

In other words, it appears Plastics Europe intends to increase emissions for 2001 to reflect recent advances in emission detection of the kind described in section 2. e) for Climate Trace. It does not intend to include the far larger emissions increase caused by a) the reduced accessibility of current reserves. And b) the decline in the relative importance of Saudi oil and gas, from world leader to a mere 6% of the total, and the concomitant rise of US oil and gas to almost 20% of the global total, some 70-80% of which is fracked.

Ecoinvent, on the other hand, increased the carbon footprint of PET by 26% at the beginning of 2024, based on data reflecting the global supply situation in 2019. (2) Why 2019 was chosen in 2024 is a mystery. As we have seen, abundant current data on oil and gas production emissions are freely available. By 2024, Carbon Dioxide Equivalent Emissions from Energy, Process Emissions, Methane, and Flaring in millions of tonnes of CO_2 equivalent had already increased to 40,812, up from 39,165 in 2019. (3) According to Sustainable Plastics, "the Ecoinvent database now covers 90% of the global production of crude oil and nearly 80% of natural gas. In addition, the update introduces regional consumption mixes for crude petroleum oil to North America and Europe." (4)

We find this too perplexing. As shown in Figure 7, North America and Europe combined account for a mere 5% of global PET production. Perhaps Sustainable Plastics has misunderstood, but the oil consumption mix for China and India is the relevant metric, as that's where most - 85% - of global PET comes from. Either way, Nova Institute, Germany, analysed the effect of these updates on the carbon footprint of fossil-based PET. Compared with results based on the previous Ecoinvent database, PET saw an increase in impact of 26% (water consumption should have been similarly augmented, but this seems not to have occurred). (5) Nova expected the updates to the Ecoinvent database to have a "significant impact on European policy". Surprisingly, despite being primarily provided by Ecoinvent and for reasons we cannot understand, the database underpinning the EU PEF does not appear to have been updated. We cite one (of many) Environmental Data Platforms for Apparel & Footwear, Carbonfact, on the topic:
".....In the EF3.1 database, these improvements do not yet appear to be reflected, as the climate change impact of fossil-based PET is approximately 20% lower than in the latest version of the Ecoinvent database (3.12 kg CO_2e)." (6)

These databases are pay-for-play. If Ecoinvent has not been paid to update the PEF database, even if it knows the old data is grievously misleading, presumably, it will not update it.

The French PEF database does not appear to have been updated either.

The MSI, on the other hand, not only did not increase the impacts of PET and polyester in line with the Ecoinvent findings, but in December 2023, it reduced them. The Apparel Impact Institute announced in May 2024 that 2022 emissions for the apparel sector had declined 1.17 percent from 2021. The following explanation was provided: "Our calculations use refreshed MSI data, the details of which can be viewed in the change log for Version 3.7 (December 2023). As described in the change log, all global warming midpoints and scores have changed due to the update to the LCA for Experts (formerly known as GaBi) database." (7) Or, as the MSI put it: "PET – all impact areas have changed due to an update in the background dataset for a precursor material." (8) As we will see, the EU PEF also appears to have reduced the purported climate impact of polyester. We can think of no explanation to justify this reduction (see Annex 1 for Cascale's response).

(1) https://plasticseurope.org/sustainability/circularity/life-cycle-thinking/eco-profiles-set/
(2) https://www.sustainableplastics.com/news/new-ecoinvent-lca-database-shows-higher-carbon-footprint-fossil-plastics
(3) https://www.energyinst.org/statistical-review/resources-and-data-downloads
(4) https://www.sustainableplastics.com/news/new-ecoinvent-lca-database-shows-higher-carbon-footprint-fossil-plastics
(5) https://www.sustainableplastics.com/news/new-ecoinvent-lca-database-shows-higher-carbon-footprint-fossil-plastics
(6) https://www.carbonfact.com/blog/knowledge/polyester-carbon-footprint
(7) https://apparelimpact.org/resources/taking-stock-of-progress-against-the-roadmap-to-net-zero-2024/
(8) https://howtohigg.cascale.org/higg-index-tools/higg-product-tools/higg-msi/dive-deeper/higg-msi-change-log/#section1

That anyone can feel comfortable advising consumers what constitutes a 'greener' purchase based upon such questionable foundations is beyond us. As shown in Figure 7, European (including Turkish) production of PET polyester represents a mere 3.9% of global output. Even if the data were current, using European PET production to represent global PET impacts is not scientifically justified. Regrettably, this misrepresentation has been picked up by global regulators. Indeed, the chair of the EU PEF Technical Secretariat for Apparel & Footwear argued as recently as 2024 that if natural fibers were unhappy with their relative PEF scores, the responsibility to provide more accurate data lies not with the multi-millionaire owners of Chinese and Indian PET and polyester plants, but with poor global farmers. (1)

LCAs are expensive. We have heard that a recent LCA of a handful of Californian farms undertaken by the EU database supplier just mentioned, PRé Sustainability (2) took 2 years and cost US$110,000. To make this LCA EU PEF compatible would, we are told, cost almost the same again. The cotton LCA representing about two-thirds of world production, prepared by Cotton Incorporated, cost about $265,000 in 2016.

As we have seen, what constitutes accurate and representative data changes fairly rapidly, so after all this expense, LCAs can have a validity of as little as 6 years, and after 15 years are generally regarded as obsolete. You can create an ISO-compliant LCA using various boundaries and methodologies, each of which would result in different purported outcomes. A scientifically valid database would only include LCAs using the same boundaries and methodologies. (3)

Who has the funds to build and maintain such a database?

Instead, commercial databases collect and collate any reasonably authoritative and compliant LCA for the product or process they are interested in. They then present these numbers as 'valid data' to be purchased. But as we have seen for PET and polyester, the fact that a number originates from an LCA does not make it science.

LCA and database providers have expended considerable effort in convincing regulators that what they can offer is all that is required to enable science and fact-based sustainability claims. One example: Lobby Facts EU reports that the aforementioned PRé Sustainability spent 250,000€ in 2019 alone, lobbying EU institutions. (4)

Quite simply, this contention is false. As we pointed out in a paper published in early 2026, (5) LCAs fail to cover some of the most important aspects of what makes a fiber sustainable. As we have seen from Figure 10, despite the fact that polyester constitutes c56% of the global fiber supply, the LCAs needed to enable fact-based comparisons for polyester do not exist. The net outcome, using the EU PEF as an example is illustrated by two screenshots taken in August 2025, the Glimpact website, showing the purported impact of 2 identical 150 gram 'weft knit, 'bath dyed', tee-shirts (all other "characterisations" marked 'no' or 'unknown'), one made of 100% polyester and the other, of 100% cotton.

Figure 15: Glimpact T-Shirt Coton Classique 150g — Traceability Simulation on the next page >>

(1) https://www.youtube.com/watch?v=LshDE1bHNM8
(2) https://pre-sustainability.com/
(3) https://gcbhr.org/backoffice/resources/the-rise-of-lcas-and-the-fall-of-sustainability.pdf
(4) https://www.lobbyfacts.eu/datacard/pr%C3%A9-sustainability-bv?rid=837882138460-68&sid=120134
(5) https://baumwollboerse.de/en/competencies/publications/report-on-un/

Figure 15: Glimpact T-Shirt Coton Classique 150g — Traceability Simulation

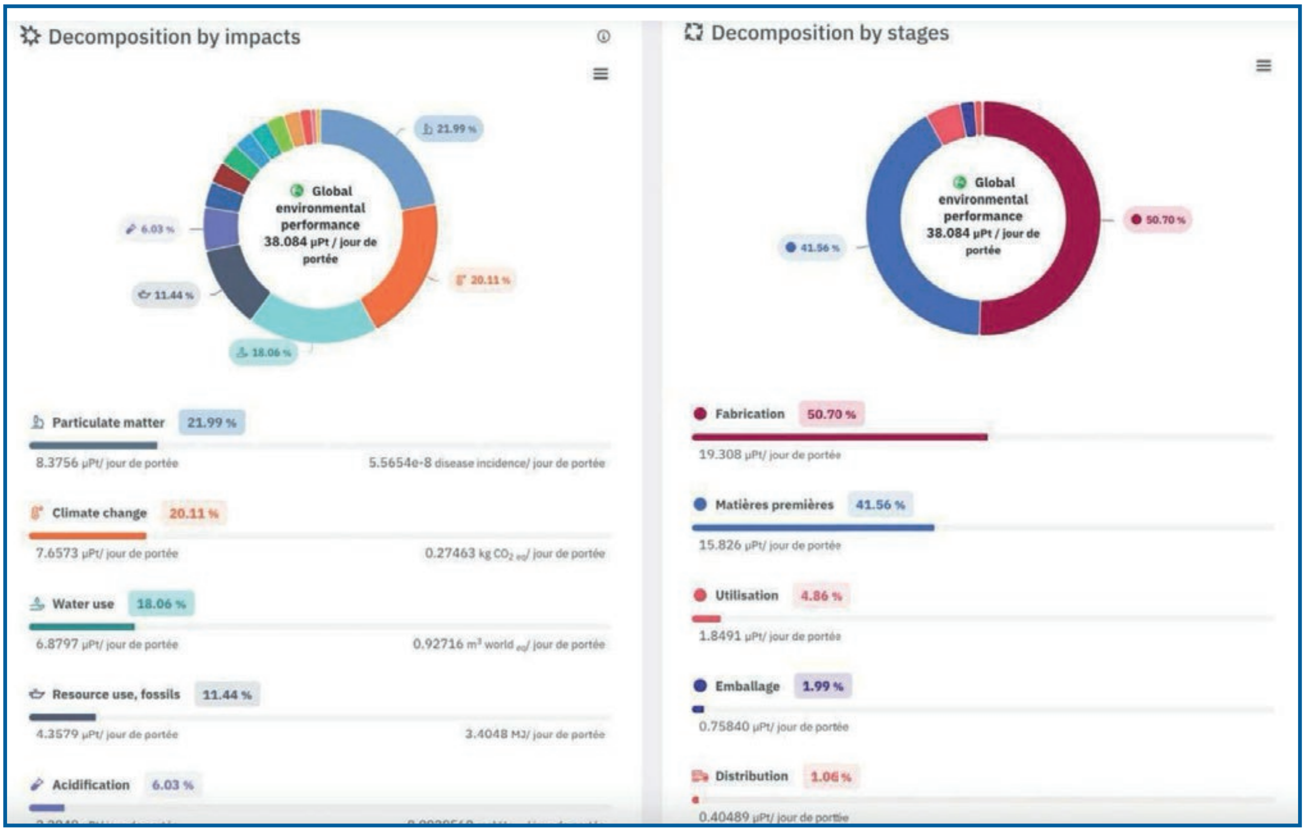


Figure 15: https://tool.glimpact.com/ecodesign/6873/11393/results screenshot taken 01/08/25

Figure 16: Glimpact Polyester Equivalent Traceability Simulation on the next page >>

Figure 16: Glimpact Polyester Equivalent Traceability Simulation

Figure 16: https://tool.glimpact.com/ecodesign/6874/11394/results Screenshot taken 01/08/25

NB."µpt" (micropoint) is the unit of measurement used within the EU's Product Environmental Footprint (PEF) methodology, to express the total environmental impact of a product or service on a single scale. By normalizing and weighting different environmental impact categories, a single µpt score is generated to allow for easy comparison between different products and activities. Here, we should point out that normalizing and weighting, whilst standard procedures in composite indices, are completely subjective. Indeed, the normalisations and weightings used in both PEFs, for example, are seen by many as outdated and unrepresentative of current global concerns.

As we can see from Figures 15 and 16, the cotton tee has a purported impact per day of wear of 38 µPt. The polyester version scores only 21µPt per day of wear. As Peftrust, a reliable source on the EU PEF, puts it: "Remember that the lower the PEF score, the lower the environmental impact of the product."[1]

So, according to the EU PEF, all other things held equal, a cotton T-shirt is 80% more environmentally harmful than a polyester one. If you have followed the report this far, you will be aware that there is no science behind that claim.

[1] https://www.peftrust.com/2023/06/15/the-durability-challenge-embracing-sustainable-practices-for-fashion-brands-and-consumers/

Two quick asides:

1 The number of wears varies by category. The greater the number of wears, the lower the impact per wear. (1)

But this can be modified by selecting:

a) a 'quality multiplier'. This is a physical durability measure based on performance tests, and

b) a reparability multiplier that is a function of price, the availability of spare parts, and whether the brand offers repair services and/or information on repairs.

Reparability seems to have a marginal impact. For example, with our polyester simulation, increasing the price from €5 to €100 reduced the purported daily impact by only 1μPt. In contrast, increasing the **physical** durability to the maximum reduced the purported daily impact of a €5 tee by half to 10.8 μPt.

As shown in Table 12, in Appendix 3, which was copied from the website of the leading B2B fabric supplier, Szoneier, (2) polyester generally performs better than cotton on Martindale, pilling, and fade tests. In other words, the PEF's 'quality', or more precisely, durability multiplier, will inevitably enhance the ostensible environmental advantage of polyester over cotton garments.

2 Since 2020, in an attempt to deflect criticism of the Higg MSI scores appearing to irrationally favour plastics, the SAC/Cascale has claimed that adding impacts into a single score is misleading. The single score was deleted from the Higg MSI website in 2021. But the PEF is a single score, and the SAC/Cascale led the PEF Technical Secretariat for Apparel and Footwear from its inception. (3)

If Cascale has serious reservations about combining 4 or 5 different normalised variables into a single score for the MSI. How much greater must those reservations be when it comes to combining 14-16 variables into a single score, as is the case with the French and EU PEFs?

Since 2022, to deflect further criticism, the SAC, now Cascale, and Higg operators, Worldly, have also argued that impacts and scores should only be compared within fiber groups, not between them. (4) The Technical Secretariat completed its work in June 2025, publishing a PEFCR for A&F. "The PEFCR for apparel and footwear does not allow the use of the single score for business to consumer communications, nor its use for comparison against the representative products." (5)

But

a) the PEF is intended to assist consumers in choosing more sustainable garments, and they may well compare a cotton shirt with a polyester one, or a viscose dress with a silk dress.

b) as shown in Table 9 in Appendix 2, the MSI itself includes a comparison tool, and this does not permit you to compare within a fiber category, only between them. For example, conventional cotton cannot be compared with recycled or organic cotton using this tool, but as Table 10 shows, it can be used to compare cotton with polyester or silk. Indeed, it can be used to compare fibers by each variable, eg, global warming, eutrophication, and water scarcity, across the different production stages.

(1) https://iwto.org/wp-content/uploads/2024/10/Joint-Statement-on-Durability-COTANCE-CEC-IFF-IWTO_010728.pdf
(2) https://szoneierfabrics.com/
(3) https://cascale.org/about-us/advocacy/pef/
https://cascale.org/resources/blogs/driving-sustainable-change-our-role-in-the-pef-initiative/
https://cascale.org/resources/press-news/news-updates/cascale-celebrates-official-launch-of-pefcr-for-apparel-footwear-in-brussels/
(4) https://www.just-style.com/news/sac-responds-to-consumer-watchdog-guidance-around-higg-msi/?cf-view
(5) https://environment.ec.europa.eu/news/new-eu-rules-measuring-environmental-impact-clothes-and-shoes-2025-06-25_en

We are baffled as to why neither TE nor Cascale, nor the agencies they collaborate with and support, the Policy Hub and the Global Fashion Agenda, for example, have made their objections to the use of single scores, narrow LCAs, and comparative fiber assertions, clear to the French and EU authorities.

As it is, the EU Commission is convinced that the: "Product Environmental Footprint Category Rules (PEFCR) for Apparel and Footwear, is a scientifically grounded, industry-supported framework that enables consistent measuring of apparel and footwear's impact on the environment." [1] Judging by the assertions made by Cascale and TE shown in Annexes 1 and 2 to this paper, DG Env is mistaken. The PEF framework is not supported by two of the industry's leading organisations.

To return to our topic and focus on the raw material, which is the subject of this paper, for the PEF for a cotton tee, the raw material constitutes 42% of the environmental impact. All other variables held constant, switching the fiber to polyester reduces the raw material impact to 17% of a significantly lower total. This is consistent with the narrative that major fast fashion and athleisure brands have been promoting since at least 2017, when the Global Fashion Agenda recommended that all apparel brands replace 30% of their cotton with polyester by 2030. [2] It is, however, inconsistent with the European and broader international objective of reducing plastic production. Nor is it consistent with the facts when polyester is traced back to its current sources in terms of manufacture and feedstock, as outlined in this paper. The cotton tee is reportedly associated with a climate change impact of 7.7 µPt/jour de portée. For the polyester tee, it's only 5.2.

Interestingly, a 2023 study by EURIC [3] found that, using the previous EU database and a functional unit of 52 wears/washes, the total CO_2e impact for a 100% cotton tee was 3.4 µPt. That for a polyester tee was not lower but (slightly) higher. It was 3.6 µPt. [4]

We do not understand how recent advances in our knowledge of petrochemical impacts, and indeed Ecoinvent's own estimates, could result in polyester suddenly having a relatively lower climate impact. We would further point out that, as shown in Figures 23 and 24 in Appendix 2, replacing cotton or polyester in our Glimpact model with silk increases the purported impact per wear to 236 µPt. Silk, for which the feedstock is caterpillars and fast-growing hardwood trees, causes 11 times more environmental damage than polyester, for which the feedstock is oil and gas. Replacing the fiber choice with cashmere increases the impact to 664 µPt.

We cannot explain this collapse in scientific standards, let alone objectivity. That so many of those involved are willing to damage the earning potential of millions of people, who are among the poorest on the planet, based upon such flimsy and glaringly inaccurate information, is concerning. Those involved in the PEF insist that what we have is the best guide that science can currently provide, and that the database and methodology will improve with time. [5]

As we have shown, the first contention is not substantiated. The second may well be correct. The data may improve. However, it misses a vital consideration. We are talking about cash crops. These are the crops that provide farmers with essential funds for everything from their children's education to healthcare. Curtailing this income for even a handful of years will have lasting impacts. We question whether it is ever moral and ethical to damage the livelihoods of the world's poorest without any compensation, particularly when there is no robust data to substantiate the merits of these actions.

It is disappointing that this trend of offering a free pass to the richest appears repeatedly in legislation. For instance, the London-based ODI has calculated that the EUDR, or European Union Regulation on Deforestation-free Products [6]

1. Email of 24/09/2025 from DIRECTORATE-GENERAL ENVIRONMENT to TT
2. https://baumwollboerse.de/en/competencies/publications/report-on-un/
3. https://euric.org/resource-hub/reports-studies/study-lca-based-assessment-of-the-management-of-european-used-textiles
4. https://euric.org/images/Position-papers/lca-based-assessment-of-the-management-of-european-used-textiles_corrected.pdf (Table 19)
5. https://www.youtube.com/watch?v=LshDE1bHNM8
6. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1115&qid=1687867231461

could set some of the poorest countries' exports back by 10% and reduce an individual country's GDP by 1%, because increasing compliance costs exclude producers unable to cover them, and exports will be reduced. (1) In contrast, the EU Regulation on methane emissions only covers the energy sector and not petrochemicals, and the introduction will be phased, beginning with reporting. Any ban on imports will be postponed until 2027, and the methane database will be created and funded by the EU. (2)

European nations have a proud scientific heritage. For A&F, the PEF database is being presented as accurate, current, and representative of global production. It isn't. As we have just shown, for polyester, the most important and increasingly dominant fiber in the global supply chain, the PEF database underestimates both the total impact and the variability of that impact according to source locations.

We cannot explain this collapse in scientific standards, let alone objectivity. That so many of those involved are willing to damage the earning potential of millions of people, who are among the poorest on the planet, based upon such flimsy and glaringly inaccurate information, is concerning.

(1) https://theconversation.com/new-eu-trade-rules-could-put-poor-countries-in-a-billion-dollar-green-squeeze-228537

(2) https://caneurope.org/content/uploads/2024/02/Unveiling-the-key-elements-of-the-methane-regulation-compromise-agreement.pdf

4. SYSTEM-LEVEL IMPLICATIONS AND KEY FINDINGS

In considering traceability and its merits, there are several important distinctions to be made between

a) feasibility, which asks whether tracing is technically possible;

b) practice, which evaluates whether tracing is happening;

c) reasonability, which considers whether the effort is justified, and

d) policy interpretation, which reflects how current narratives may influence decisions. [1]

This paper answers **a)** unambiguously. For initiatives, brands, and international organizations to claim that fiber traceability is required/achieved by focusing solely on farmed fibers is highly misleading. Polyester can be traced back to the oil well, or gas play, with as much or as little difficulty as cotton can be traced to the farm.

This paper also answers **b)**. For polyester, representing 56% of the global fiber supply, tracing is not taking place. Serious questions remain unanswered, and purported impacts are incorrectly assessed. Just one example, toxicity. Agricultural chemicals have been closely examined and evaluated since Rachel Carson published Silent Spring in 1962. [2] In 1962, total synthetic fiber production was less than 1.4 million tonnes. [3] Today, polyester alone is about 70 million tonnes. [4]
Plastics are just beginning to have their own Silent Spring. The work of Plastchem in identifying toxic chemicals in polyester production and consumption was discussed in section 2. a).
But what we don't know cannot be measured. As this paper has pointed out, of the 2,566 chemicals used, present, or released in the production and consumption of PET, 806 are known to be hazardous, but double that amount,1,609 chemicals might be hazardous or not. Nobody has tested them. This means LCAs have no means of including their potential, even probable, toxicity, and automatically suggest that no threat exists. We see this clearly in the Glimpact Traceability simulations discussed in section 3 above. The cotton tee purportedly has human toxicity impacts, cancer, and non-cancer of 2.1679e-10 CTUh/ jour de portée and 4.1119e-9 CTUh/ jour de portée. While for polyester, the claimed toxicity impact is far lower: 1.4055e-10 CTUh/ jour de portée and 1.2643e-9 CTUh/ jour de portée, respectively. [5] This does not match the current global concern about plastics. As this paper has demonstrated, Identical question marks hang over polyester's purported water consumption and carbon emissions. **With so many unknowns for polyester, current scores cannot be reliable. Is it ethical to advise consumers that they are?**

This paper does not consider **c)** reasonability — whether the effort is justified. Nor is this for us to say. What is clear from our analysis is that it is vital to distinguish between the 2 primary justifications. If traceability is desired to ensure that materials have not been sourced from regions characterized by human rights abuse or from countries on a sanctions list, it is relatively straightforward and cost-effective to implement. If it is to calculate environmental impact at the product level, this is more complicated and considerably more costly, particularly for agricultural products, where different temporal and spatial conditions and calculators will come up with very different values. LCAs were designed for industry, not agriculture. The benefits for biodiversity and soil organic carbon are not captured, overstating negative and understating positive outcomes of agro-environmental practices. LCAs are, furthermore, very expensive to implement and maintain. This puts them beyond the reach of most farmers and SMEs (Small to Medium Enterprises). Legislation, including PEFs and by extension ESPR, is tied to specific databases approved by appointed LCA providers. This means most farmers and SMEs will have to use generic data, in which case, what is the point of the considerable expense in traceability? Is it even clear that reporting catalyses change, let alone is cost-effective?

[1] Email from SG 10/12/2025
[2] https://www.penguin.co.uk/books/57236/silent-spring-by-rachel-carson-introduction-by-lord-shackleton-preface-by-julian--huxley-afterword-by-linda-lear/9780141184944
[3] https://documents1.worldbank.org/curated/en/453921468142166726/pdf/multi0page.pdf
[4] https://2d73cea0.delivery.rocketcdn.me/app/uploads/2025/09/Materials-Market-Report-2025.pdf
[5] https://tool.glimpact.com/workspace/ecodesign

Finally, **d)** policy interpretation, which reflects how current narratives may influence decisions. As this paper makes clear, regulations founded on SBTis to PEFs are LCA-based and so, by definition, only as reliable as the LCAs' underlying data and methodology. For fibers, we simply do not have the data, so highly misleading calculations are being made and presented to legislators, consumers, and the electorate as robust, scientific, and impartial, covering the full product lifecycle and treating all materials equally. As this paper has amply demonstrated, this is incorrect. The misrepresentation and so misdirection is further compounded by the fact that the LCAs and LCA-based tools concerned do not include socio-economic impact. As the preamble points out, UN norms and standards require that "Sustainability in the context of garment and footwear value chains means that all activities, throughout a product's life cycle, take into account their environmental, health, human rights and socioeconomic impacts." The significant negative socio-economic impacts of polyester production and consumption, and the significant benefits of farmed fiber cultivation, are not included in current LCA-based sustainability and impact evaluation.

Finally, we are talking about clothing, not washing machines or batteries. As many critics of the PEF have observed, apparel is not like other consumer durables. Durability cannot be designed into the product. As one of our reviewers observed, clothing purchases are governed by desire, emotional decision-making, and impulse. Durability may just mean an ugly, hardly worn garment that never breaks down in a landfill. By contrast, a poor durability score will be turned on its head when a treasured item is nursed, handwashed, repaired, and worn for a decade or more. [1] Simply put, the impact that matters is not impact at the checkout; it's the impact per wear, and the number of wears is influenced by everything from financial security to cultural norms. [2]

We doubt that any accounting tool can capture this nuance. Until it can, reality negates the entire raison d'etre of any PEF or sustainability index.

We offer no recommendations in light of our analysis. Our aim, rather, is to provide an assessment that will prove useful to those creating and responding to legislation and sustainability strategies.

Bates Kassatly, and Townsend, April 2026.

[1] Email from Meriel Chamberlin 8/12/2025

[2] https://www.veronicabateskassatly.com/read/sustainable-fashion-could-it-all-be-in-the-hands-of-the-consumer

APPENDIX

APPENDIX 1: WHAT IS POLYESTER, AND WHERE IS IT COMING FROM?

Figure 17: The Path of Plastics from Raw Materials to Resin, adapted from Plastics Europe Eco-profiles for determining environmental impacts of plastics

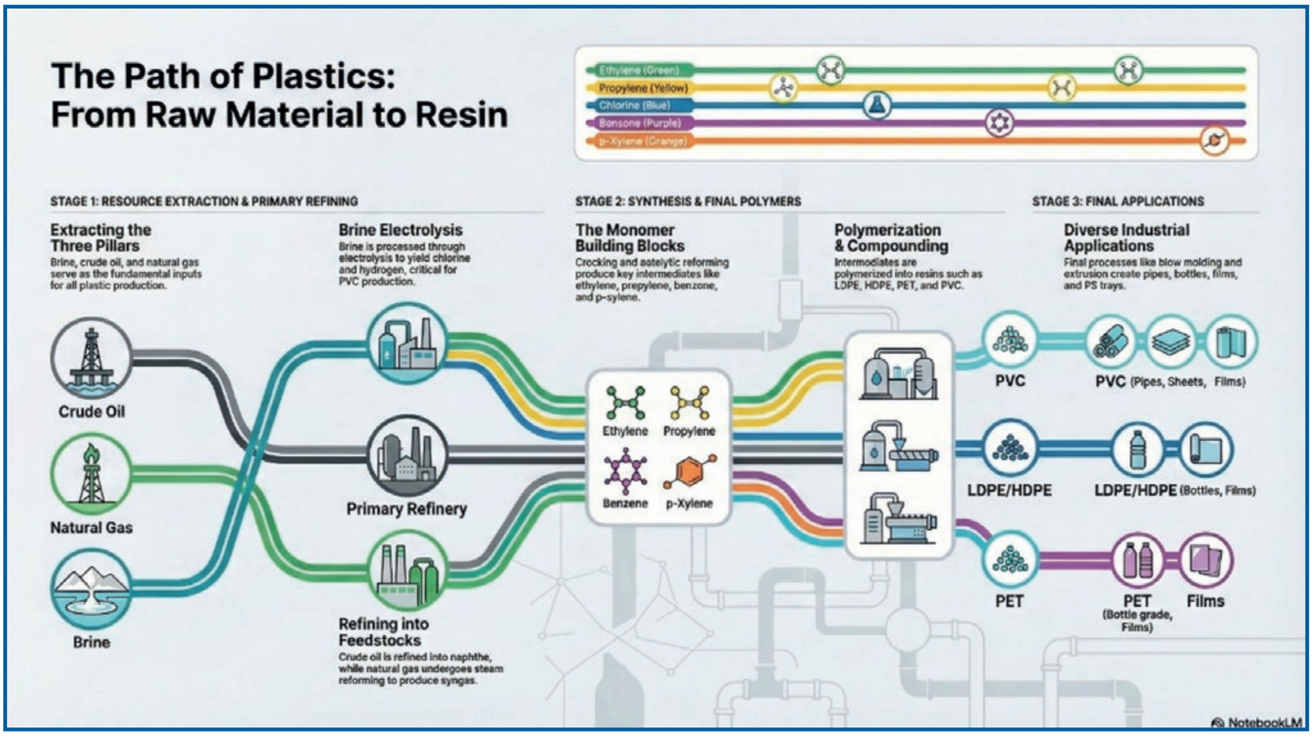


Figure 17: https://plasticseurope.org/sustainability/circularity/life-cycle-thinking/eco-profiles-set/

This is a paper on traceability, not polyester, and we are economists/statisticians, not chemists. Broad brush, to quote Science Direct," Polyester is defined as a category of condensation polymers that contain the ester functional group in their main chain, formed by the reaction of alcohols with acids through ester linkages. While some polyesters occur in nature, the term typically refers to synthetic polymers, such as poly(ethylene terephthalate) (PET)." (1)

This paper covers only PET. The same material that is used to produce plastic bottles: "Polyethylene terephthalate (PET) items referenced are derived from terephthalic acid (or dimethyl terephthalate) and monoethylene glycol, wherein the sum of the terephthalic acid (or dimethyl terephthalate) and monoethylene glycol reacted constitutes at least 90 percent of the mass of monomer reacted to form the polymer." (2)

The primary feedstock for Purified Terephthalic Acid (PTA) is in turn paraxylene (PX), an aromatic hydrocarbon separated from crude oil during the refining process. (3) The most common source of feed for PX is heavy naphtha from refinery streams or condensate from gas fields. (4)

(1) https://www.sciencedirect.com/topics/materials-science/polyethylene-terephthalate#:~:text=Polyester%20is%20defined%20as%20a,ethylene%20terephthalate)%20(PET)
(2) https://napcor.com/about-pet/
(3) https://www.jgc-indonesia.com/en/news/338/introduction-to-purified-terephthalic-acid-pta-process
(4) https://www.digitalrefining.com/article/1001045/the-petrochemistry-of-paraxylene

Manufacturing monoethylene glycol, or MEG, on the other hand, primarily involves the oxidation of ethylene. "There are two main routes for MEG production: one is the Olefin/EO(Ethylene Oxide) Route starting from either naphtha, ethane, or methanol, the licensors include Shell, SD, UCC and etc. And the other is the DMO(dimethyl oxalate) Route, newly emerged in China, starting from syngas." (1) Syngas is a man-made gas created through chemical processes using waste products as feedstocks. (2) Coal-to-MEG also exists. (3) The final stage in polyester's raw material production is PET chip manufacture. There are 3 grades: 1. Fiber-Grade Polyester Chips primarily for spinning polyester staple and filament fibers used in apparel fabrics; 2. Bottle-Grade Polyester Chips, and 3. Film-Grade Polyester Chips. (4) Some companies, like Hubei Decon, only produce chips. Others, such as Reliance, for example, produce chips, fiber, and fabric.

As for identifying which plants are producing the polyester that brands are purchasing, that should be the easiest part, because the transaction is unlikely to be more than one step removed. Indeed, the Reliance Industry website boasts 'Exclusive Partnerships' with an assortment of apparel household names or their subsidiaries, including Adidas, Burberry, Hugo Boss, and Gap (see Figure 33 in Appendix 3). (5)

Even if brands only know the country of origin of their polyester, as shown in Figure 7 in the main body of this report, there is a 75% chance that the country is China. Contrary to the assertions of multiple databases, including the Cascale/Worldly Higg MSI and the EU and French PEFs, there is only a 3% chance that the polyester came from Europe (including Turkey).
Geographically, almost all polyester production comes from Asia (93%). This has been the case for decades, albeit the share represented by China is growing. China represented 72% of total output in 2019. In 2024, it was 75%. Similarly, India represented 9% of the global polyester supply in 2019, but 10% (of a larger total) in 2024. The least important players in 2024 were Turkey, 2%; North America, Europe without Turkey, the Middle East and Africa, and South America, each of which accounted for about 1% of global polyester production. (6)

Indeed, not only is there a 75% chance that the polyester came from China, as Table 7 shows, there is an equally high chance that it came from one of just 10 Chinese manufacturers, very likely located in Jiangsu or Zhejiang provinces. (7) If state-owned, specialty polyester chip producers Hubei Decon (8) are correct, the total capacity of these 10 manufacturers alone, exceeds China's current annual output (50 million tonnes) by over 20%.

Table 7: Top 10 Polyester Manufacturers in China 2021/22 on the next page >>

(1) https://www.slchemtech.com/meg-plant/
(2) https://www.gasdata.co.uk/whats-on/syngas-what-is-it-how-is-it-made-where-is-it-used/
(3) http://www.asiachem.org/en/coalchem_201702212
(4) https://www.polyestermfg.com/pet-chips-introduction/
(5) https://www.ril.com/about/products-brands
(6) Source: Wood Mackenzie
(7) https://www.polyestermfg.com/top-10-polyester-manufacturers-in-china/#comments
(8) https://www.polyestermfg.com/about/

Table 7: Top 10 Polyester Manufacturers in China 2021/22

Ranking No.	In 2021			In 2022 (Predicted)		
	Company Name	Yearly Capacity (Ton)	Market Share	Company Name	Yearly Capacity (Ton)	Market Share
1	Hengyi	8470000	12.90%	Tongkun	10800000	14.60%
2	Tongkun	7400000	11.30%	Hengli	10000000	13.50%
3	Xin Feng Ming	5700000	8.70%	Hengyi	9770000	13.20%
4	Sanfame	3500000	5.30%	Xin Feng Ming	9500000	12.80%
5	Sinopec	3430000	5.20%	Sanfame	6500000	8.80%
6	Hengli	3200000	4.90%	Sinopec	4130000	5.60%
7	Yisheng	2700000	4.10%	Yisheng	3200000	4.30%
8	Shenghong	2280000	3.50%	Shenghong	3000000	4.10%
9	China Resources	2100000	3.20%	Wankai	2400000	3.20%
10	Wankai	1800000	2.70%	Billion Holdings	2000000	2.70%
	In Total	40580000	61.90%		61300000	82.80%

Table 7: https://www.polyestermfg.com/top-10-polyester-manufacturers-in-china/#comments

These numbers are roughly corroborated by Wood Mackenzie (WM). For 2024, summed over Polyester textile filament, Polyester industrial filament, Polyester staple fiber, Polyester filament spunbonded, and Polyester bulked continuous filament (used mainly for carpets), WM calculates that the 10 largest producers in the world are all in China. Reliance Industries was ranked number two in global capacity in 2010 and 2015. It was ranked 6th by capacity in 2020. By 2024, it was no longer in the top 10. Top producers Zheijiang Tongkun and Zheijiang Xin Feng Ming, in WM's estimation, have a capacity of just under 8 and 6 mmt respectively.

Hengyi shows as 3 different producers in the WM ranking, with a total capacity of ≈ 7mmt. Hengli, WM believes, has not expanded capacity as planned and is ranked 9th in the world. WM's capacity estimates include fiber from both virgin and recycled bottle waste (rPET). The vast majority of plants are either one or the other, but many virgin polyester plants will use some volume of recycled PET bottle feedstock to obtain sustainability certifications.

In other words, the two countries that the apparel sector would need to obtain production data on if it wishes to make any pretense of traceability, sustainability, and impact measurement are China and, to a lesser extent, India.

Contrary to common assertions in sustainable textiles and apparel, this is hardly an insurmountable task. Data on only a few producers is required compared to the hundreds of gins that need to be evaluated to get any idea of the impact of cotton production. And instead of thousands of farms, data on feedstock will likely only have to be gathered for a handful of countries. These should not be difficult to identify. Even in the case of PET facilities that are not tied by contract, sources can be deduced. To illustrate the point, we consider Russian and Iranian oil supplies. These 2 countries were selected because a) as Table 5 in the main body of the report shows, in 2024, Russia and Iran were the 2nd and 3rd most important producers in the global supply of oil and gas. b) As described throughout the report, some of the highest emissions come from Russian and Iranian extraction. And c) Russia and Iran are both subject to sanctions from the USA, the EU, and others.

In 2023, the oil supply in China (total oil produced or imported, minus oil exported or stored) equalled 30,804,260 terajoules.[1] One TJ equals 170.6 barrels of oil. Thus, the oil supply in China in 2023 amounted to 5.3 billion barrels. In 2023, 73.9% of China's oil supply was imported. This included 2.1 million barrels per day imported from Russia (766.5 million barrels per year).[2] In other words, in 2023, Russia accounted for 15% of the total supply of oil in China.

By the same methodology, in 2023, the oil supply in India equalled 11,345,640 terajoules[3] equating to 1.9 billion barrels. In 2023, 88.2% of India's oil supply was imported,[4] including 1.8 million barrels per day imported from Russia (657.0 million barrels per year).[5] Thus, Russia accounted for 35% of the total supply of oil in India in 2023.

As we just saw, in 2024, China accounted for 75% of the world's polyester production, and India accounted for 10%. Assuming the proportions were approximately the same in 2023, about 11% of the world's polyester supply produced in China originated from Russian oil, and approximately 4% of the world's polyester supply produced in India originated from oil sourced from Russia.

Sanctions on Iran have been in place for longer, and the previous Trump administration sharply curtailed Indian imports of Iranian oil.[6] Moreover, Russian oil is apparently cheaper. As a result, there appears to be little to no Iranian oil on the Indian market. By our estimates, China is the largest market for Iranian oil, accounting for about 5% of China's oil supply.

We note that there is a degree of uncertainty around these numbers due to the existence of the shadow fleet. Estimated at some 1,400 tankers or around a fifth of the overall global ocean-going tanker fleet, these vessels are used by Iran and Russia, as well as Venezuela, to evade Western sanctions. Typically, the vessels are old, their ownership is opaque, they sail without top-tier insurance cover, and they tranship sanctioned oil in third ports to disguise the origin.[7] That said, China also receives Russian oil through 2 pipelines.[8]

Reliable sources attempt to account for this, and by our best estimates, adding India and China together, about 15% of the 2023 global production of polyester began as oil in Russia, and almost 4% began as oil in Iran. In other words, in 2023, almost one-fifth of the global polyester supply was derived from sanctioned feedstock. Given that initially the major Chinese refineries shied away from Russian oil[9] in all likelihood, the percentage share in both India and China in 2024 was higher (We note that this may change as a result of punitive retaliatory tariffs placed on all Indian imports by the Trump administration at the end of August 2025, in an attempt to halt that nation's imports of Russian oil).[10]

It makes no sense for governments to impose sanctions on Russian and Iranian oil and gas, only to import them in the form of polyester. This is particularly pertinent when, as demonstrated in section 3, the current PEF database promotes polyester purchases. The need to avoid purchasing Iranian and Russian oil and gas is further compounded by the fact that it has some of the world's highest production emissions.

1. https://www.iea.org/countries/china/energy-mix#
2. https://www.eia.gov/todayinenergy/detail.php?id=61843
3. https://www.iea.org/countries/india/energy-mix#
4. https://www.iea.org/countries/india/oil
5. https://www.eia.gov/international/content/analysis/countries_long/India/pdf/India.pdf
6. https://www.thehindu.com/news/national/russia-is-not-iran-india-cant-cancel-oil-imports-on-us-demand-experts/article69910600.ece#goog_rewarded
7. https://www.reuters.com/business/energy/shadow-tanker-fleet-grows-more-slowly-western-sanctions-target-russian-oil-2025-08-13/
8. https://www.kpler.com/blog/russia-in-2024-learning-to-live-with-sanctions#:~:text=China's%20imports%20of%20Urals%20did,almost%20100%20kbd%20in%20 2023
9. https://www.reuters.com/business/energy/shadow-tanker-fleet-grows-more-slowly-western-sanctions-target-russian-oil-2025-08-13/
10. https://www.kpler.com/blog/russia-in-2024-learning-to-live-with-sanctions#:~:text=China's%20imports%20of%20Urals%20did,almost%20100%20kbd%20in%20 2023

APPENDIX 2: A NOTE ON THE COMPLEXITY, CONFUSION, AND SCIENTIFIC INCONSISTENCY OF VARIOUS ENVIRONMENTAL FOOTPRINT PROPOSALS

ADEME is a French Governmental organisation.
It is the Agence de la transition écologique, or ecological transition agency, responsible for implementing France 2030. This, in turn, represents €54 billion of investment, 50% of which **must be dedicated towards decarbonising** the economy, and 50% towards emerging, innovative players. (1)

A key aspect of this transition is the planned introduction of a Product Environmental Footprint (PEF) for select products. ADEME's environmental assessment or calculation tool is called Ecobalyse. (2)

Examination of the Ecobalyse website, however, reveals that, in a manner consistent with neither science nor the decisions of France's democratically elected representatives, the ADEME PEF for textiles does not prioritize carbon impact at all. On the contrary, Ecobalyse's approach has been to adapt the weightings of the EU PEF in an unscientific and undemocratic manner in an attempt to bolster the apparent 'sustainability' of organic cultivation (fewer than 15% of French farmers are organic, and globally this addresses the interests of a mere 4.3 million farmers. (3) As shown in Figure 18, of the 16 variables included in the EU PEF, first, Human Toxicity - Cancer and Non-cancer have been eliminated by assigning a weighting of zero to both. And then the weighting assigned to Freshwater Ecotoxicity (ETF) has been increased to 21.06%. As a result, the Ecobalyse tool now assigns ETF an equal weighting to Climate Change, in direct violation of the mandate mentioned above to dedicate efforts to decarbonising.

Figure 18: Ecobalyse Toxicity and Ecotoxicity Correctives

LE COÛT ENVIRONNEMENTAL > CATÉGORIES D'IMPACT ACV   Copier

Correctifs sur la toxicité et l'écotoxicité

La modélisation des impacts de toxicité humaine (toxicité humaine cancer et toxicité humaine non-cancer) dans la méthode PEF n'est aujourd'hui pas satisfaisante. Dans l'attente de consolider ces deux indicateurs, il est proposé de les supprimer dans le calcul du coût environnemental.

En revanche, l'indicateur d'écotoxicité (écotoxicité eau douce), est lui considéré comme plus robuste par la communauté scientifique, bien que partiel puisque ne prend pas en compte l'ensemble des impacts écotoxiques, notamment sur les milieux terrestres (polinisateurs par exemple). Par ailleurs, l'absence d'un indicateur de "biodiversité locale" dans le cadre ACV actuellement justifie de considérer temporairement cet indicateur d'écotoxicité comme un "proxy" de la biodiversité locale. Il est donc proposé de rehausser sa pondération à hauteur de 21%, c'est-à-dire au même niveau que l'impact changement climatique.

En outre, une différenciation est introduite entre les deux composantes de l'écotoxicité. Celle-ci vient de molécules organiques et de molécules inorganiques. Une écotoxicité corrigée est considérée dans le coût environnemental avec un doublement de l'impact des molécules organiques. Cette modification vient traduire le fait que le niveau de caractérisation et de quantification des effets écotoxiques des molécules organiques et inorgraniques est aujourd'hui différent. Les molécules inorganiques sont bien caractérisés et leurs effets écotoxiques bien quantifiés. Les molécules organiques sont souvent moins bien caractérisées, avec des effets écotoxiques qui sont aujourd'hui établis mais pas nécessairement pleinement quantifiés : effets cocktails, impacts sur les polinisateurs, perturbateurs endocriniens...

NB In the field of chemistry, organic compounds are substances that contain the element carbon, a common component of most pesticides, both conventional and organic (bio). Inorganic molecules are chemical compounds that do not contain carbon-hydrogen bonds, such as acids, bases, salts, and oxides.
Figure 18: https://fabrique-numerique.gitbook.io/ecobalyse/def-cout-environnemental/categories-dimpact-acv/correctifs-sur-la-toxicite-et-lecotoxicite Screenshot taken 16/11/2025

(1) https://www.info.gouv.fr/grand-dossier/france-2030-en/understanding-france-2030
(2) https://affichage-environnemental.ademe.fr/en/food-sector/calculation-tool
(3) https://www.organicresearchcentre.com/news-events/news/world-organic-ag-2025/#:~:text=Organic%20farming%20expands%20by%202.5,3.6%20percent%20in%20the%2 0EU

The justification offered by ADEME is that the Human Toxicity indicators are not robust. [1]
This is correct. But contrary to ADEME's assertions, the Freshwater Ecotoxicity indicator is equally unreliable.
In developing the PEF, the EU assigned Climate Change, along with particulate matter, the highest robustness factors of 87%. A concerningly low robustness factor of 17% was assigned to three of the 16 variables: Human Toxicity - Cancer and Non-cancer, **and Freshwater Ecotoxicity (ETF)**. Indeed, an alternative modeling of only 13 variables, eliminating all three toxicities, was proposed. [2]
Inflating the ETF indicator is unscientific and misguided. Consistency with France's internal and external commitments requires that Climate Change be given preeminence in any measure of environmental cost, and that Soil Carbon Sequestration, in line with 4 per 1000, be promoted. Not that the 86% of French farms that practice conventional agriculture should be penalised due to the perceived higher ecotoxicity of chemical fertilisers and pesticides [3] compared to those used by the 14% of French farms that are classified biologique or bio (organic). [4] In this context, it appears not all crops are equal. Leading organic cotton breeder, Sally Fox, mentioned that the roots of most annual crops biodegrade rapidly, but the biomass of the root systems of cotton plants (cotton is a perennial, cultivated as an annual) sequesters carbon for a good 5-10 years. Furthermore, 2/3 of the biomass removed from a cotton field is used for feed, and only 1/3 is fiber. Most of the cotton plant returns to the soil as organic matter to build the soil and its microbiome for the future. [5]
Indeed, "Tap roots of cotton can grow down 1 to 2 inches per day and extend to depths of 3 yards [9 feet] or more in places like California." [6]

It is indicative of the mess that impact measurement has become that apparel brand, Patagonia, has hounded cotton farmers for decades without once mentioning this benefit [7] but Patagonia is now actively promoting Kernza as a wheat substitute, due in large part to Kernza's 10 ft roots, "allowing it to absorb more carbon dioxide than many crops, and turning it into a theoretical ally in the fight against climate change." [8]

And it is not just crops; since the 1930s, the environmental impact of nomadically herded livestock has been misunderstood and misrepresented. From the Navajo in the USA, [9] to herdsmen in Inner Mongolia, rangeland restitution programs have been instituted with disastrous social and economic consequences and little to no environmental benefit. Yet the apparel sector continues to advocate for such programs. [10] As the New York Times has pointed out, an August 2025 study published in Science [11] conclusively demonstrates that the environmental impact of moving livestock has been drastically overstated. "Outwardly, the effect can look like overgrazing. But the researchers found that bison essentially allow plants to keep growing: By grazing and moving on, the animals increase the density of microbes and nitrogen, an essential chemical for plant growth, in the soil, improving the nutrition for herbivores by up to 150 percent in some areas." [12]

A few examples of what this muddled thinking means in concrete terms, using first the data underpinning the EU PEF, as illustrated by the Glimpact model (see section 3 for further detail), and then the Cascale/Worldly MSI are provided below.

1. https://fabrique-numerique.gitbook.io/ecobalyse/def-cout-environnemental/categories-dimpact-acv/correctifs-sur-la-toxicite-et-lecotoxicite
2. https://eplca.jrc.ec.europa.eu/permalink/2018_JRC_Weighting_EF.pdf
3. https://fabrique-numerique.gitbook.io/ecobalyse/textile/cycle-de-vie-des-produits-textiles/etape-1-matieres/focus-coton
4. https://agriculture.gouv.fr/french-organic-farming-2040-foresight-exercise
5. Email of 07/07/2025
6. https://www.cotton.org/tech/physiology/cpt/plantphysiology/upload/CPT-v10No1-99-REPOP.pdf#:~:text=Stretched%20end%2Dto%2Dend%2C%20roots%20of%20a%20single%20 cotton%20 plant%20can%20extend%20beyond%201000%20feet.&text=Cross%20section%20of%20cotton%20root%20showing%20epidermis%2C%20cortex%2C%20stele%20(vascu%2D%2 0lar
7. https://eu.patagonia.com/gb/en/stories/how-we-got-here-organic-cotton/story-97024.html?srsltid=AfmBOooi6Br7sSCAt6BDJA4iezegBrdtyBg3QxkXRfc01_TXw8emwoT7
8. https://www.nytimes.com/2025/09/07/business/patagonia-provisions-dirtbag-billionaire.html
9. https://fibershed.org/2022/01/05/harm-in-the-guise-of-doing-good/
10. https://baumwollboerse.de/en/competencies/publications/report-on-un/
11. https://www.science.org/doi/10.1126/science.adu0703
12. https://www.nytimes.com/2025/09/03/science/ecology-bison-migration-yellowstone.html?unlocked_article_code=1.jE8.y59V.LxMXGKLU3XXn&smid=url-share

As shown in Figure 8, for conventional cotton, impacts are stated to be based on data from Australia, Brazil, China, India, Kyrgyzstan, Mali, Pakistan, Turkey, and the USA. As we can see from Figures 19 and 20, all other variables held constant, the current PEF modelling and database claims that a tee produced using conventional cotton results in carbon emissions that are almost 50% higher than if the same tee is made of 100% polyester - 0.27463 kg CO_2e/day of wear vs 0.18599 kg CO_2e. Indeed, closer examination reveals that raw material ostensibly contributes 0.055562 kg CO_2e of the total for cotton, and only 0.026591 kg CO_2e in the case of polyester.

In other words, raw material production for the cotton tee has double the claimed carbon emissions of raw material production for the polyester tee.

Figure 19: Carbon Impact of Polyester in the EU PEF Traceability Simulation

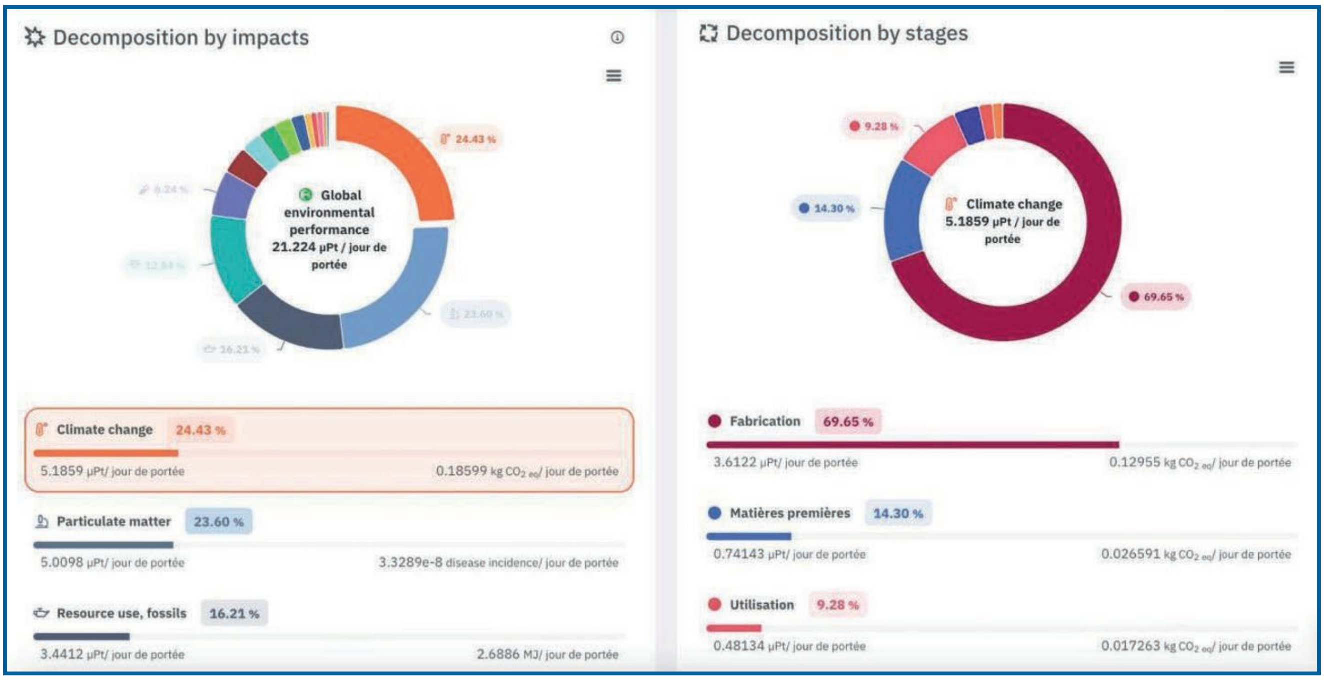


Figure 19: https://tool.glimpact.com/ecodesign/6874/11394/results Screenshot taken 04/08/2025

Figure 20: Carbon Impact of Conventional Cotton in the EU PEF Traceability Simulation on the next page >>

Figure 20: Carbon Impact of Conventional Cotton in the EU PEF Traceability Simulation

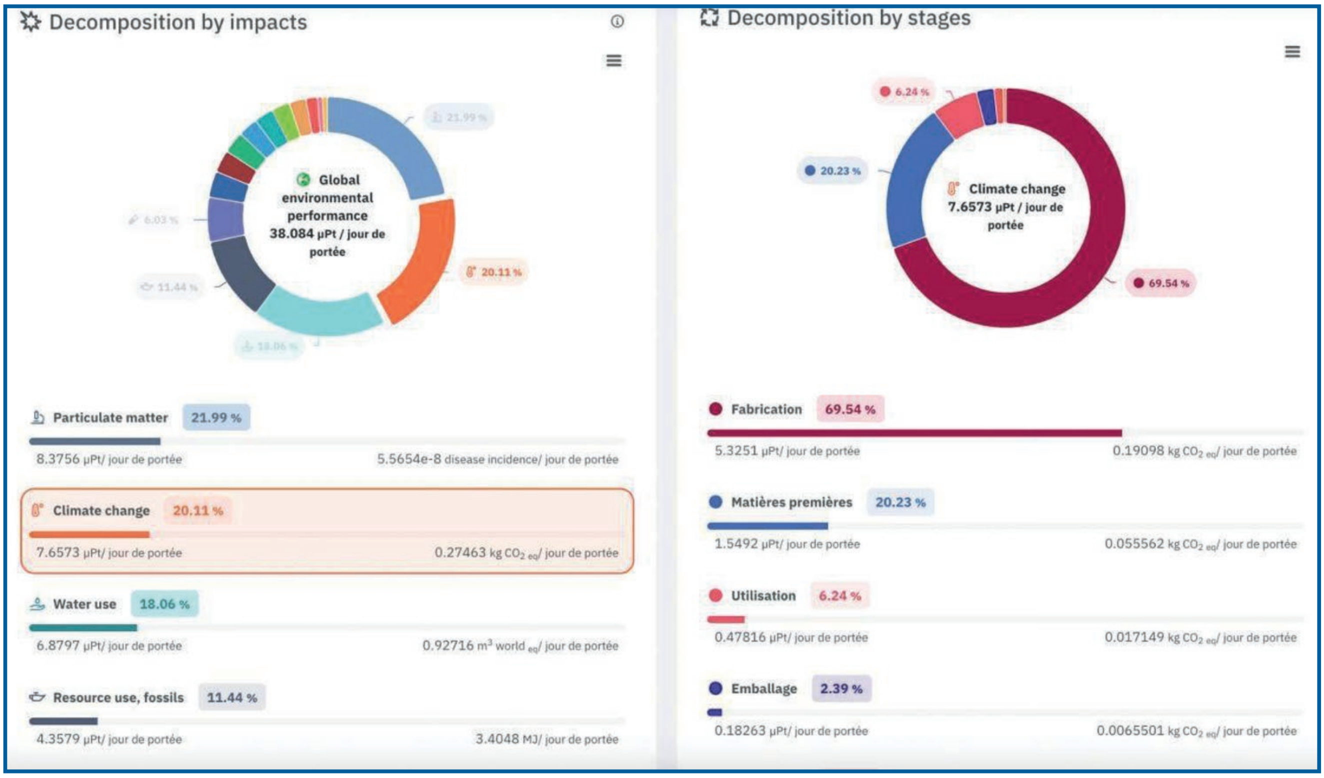


Figure 20: https://tool.glimpact.com/ecodesign/6873/11393/results Screenshot taken 04/08/2025

It is also interesting to check the purported 'Resource use, fossils' of the respective fibers. In the words of the European Commission:
"Resource use, fossils
The Earth contains a finite amount of non-renewable resources, such as fossil fuels like coal, oil, and gas. The basic idea behind this impact category is that extracting resources today will force future generations to extract less or different resources. The amount of materials contributing to resource use, fossils, are converted into MJ." (1)

As we can see from Figures 21 and 22, the PEF claims that a conventional cotton tee consumes more fossil fuels than a comparable polyester tee: 3.4048MJ/use compared to 2.6886MJ/use.

Figure 21: EU PEF Resource Use Fossils — Cotton (Traceability Simulation) on the next page >>

(1) https://green-forum.ec.europa.eu/green-business/environmental-footprint-methods/life-cycle-assessment-ef-methods_en

Figure 21: EU PEF Resource Use Fossils — Cotton (Traceability Simulation)

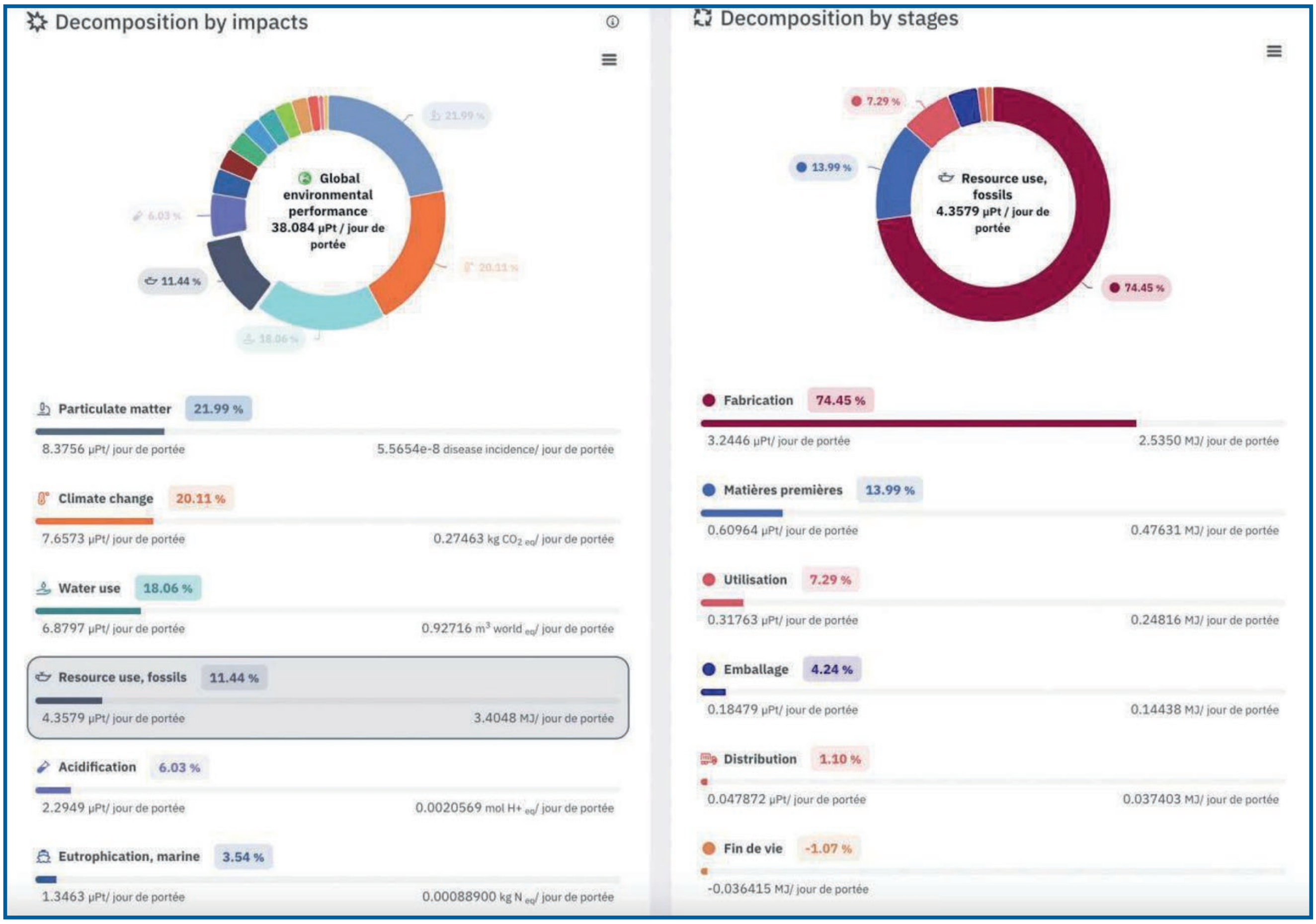


Figure 21: https://tool.glimpact.com/ecodesign/6873/11393/results Screenshot taken 06/08/2025

Figure 22: EU PEF Resource Use Fossils — Polyester (Traceability Simulation) on the next page >>

Figure 22: EU PEF Resource Use Fossils — Polyester (Traceability Simulation)

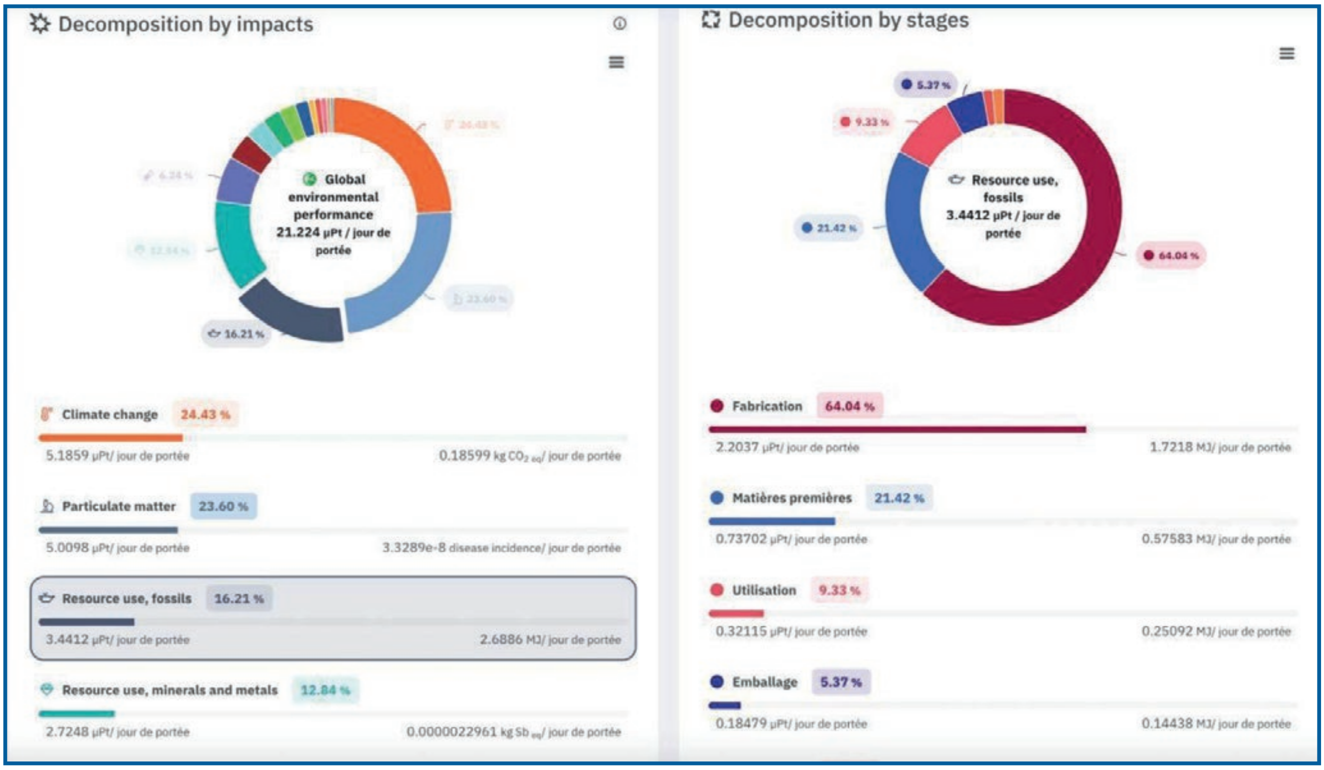


Figure 22: https://tool.glimpact.com/ecodesign/6874/11394/results Screenshot taken 04/08/25

This anomaly is even more apparent in the case of cashmere, where, as Figure 23 demonstrates, according to the EU database, the raw material production of cashmere fiber by goats eating grass and other vegetation consumes 12.093 MJ of fossil fuels/day of wear. But the raw material production of polyester directly from fossil feedstock consumes only 0.57583 MJ.

Figure 23: EU PEF Resource Use Fossils — Cashmere (Traceability Simulation) on the next page >>

Figure 23: EU PEF Resource Use Fossils — Cashmere (Traceability Simulation)

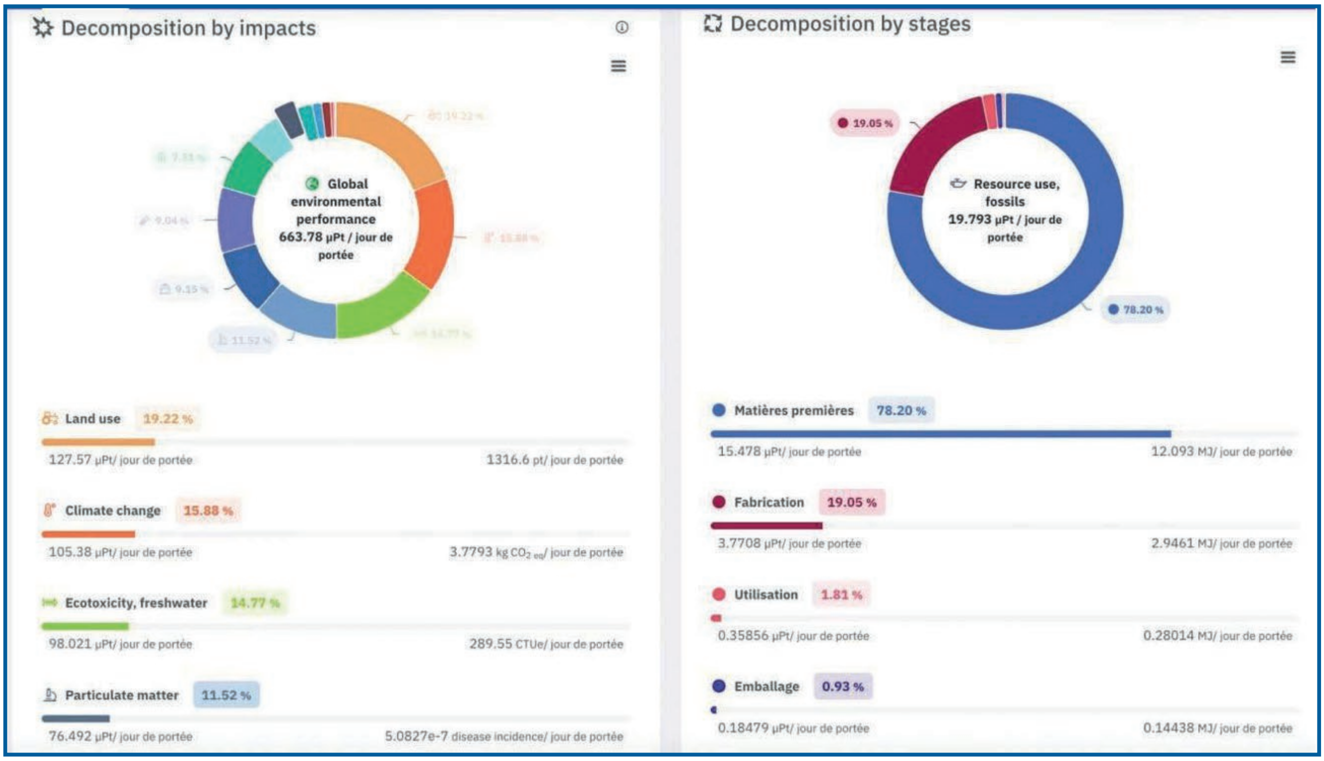


Figure 23: https://tool.glimpact.com/ecodesign/6873/11393/results Screenshot taken 04/08/25

Given that cashmere herding is hardly mechanised and consumes few pesticides and fertilisers (if any), we are baffled by this. By the same token, the PEF claims, as Figure 24 shows, that the raw material impact of silk produced by caterpillars eating mulberry leaves consumes 8.2659 MJ of fossil fuels/wear.

Figure 24: EU PEF Resource Use Fossils — Silk (Traceability Simulation) on the next page >>

Figure 24: EU PEF Resource Use Fossils — Silk (Traceability Simulation)

Figure 24: https://tool.glimpact.com/ecodesign/6873/11393/results Screenshot taken 04/08/25

You can't use most pesticides in silk cultivation, or you will kill the caterpillars, and opportunities for mechanisation are again limited. We cannot understand where or how these fossil fuels are being consumed to generate such significant impacts.

As illustrated in Table 8, similar purported impacts apply on the other side of the Atlantic. We reproduce a chart made for a report on UN agencies' pro-plastic fiber claims, published earlier this year.

Table 8: Higg Material Sustainability Index — Normalised Scores in 'Higgies' per Kilo of Generic Raw Material. Scores as of May 2025 on the next page >>

Table 8: Higg Material Sustainability Index — Normalised Scores in 'Higgies' per Kilo of Generic Raw Material. Scores as of May 2025

Fibre	Global Warming	Water Scarcity	Total RM Score
PET (Mechanically Recycled)	0.798	0.075	3.044
PET (Fossil Fuel Based)	2.880	0.504	11.957
Viscose	10.000	1.730	31.490
Wool	39.500	2.390	60.390
Cotton	2.550	56.500	77.830
Alpaca	71.900	0.000	325.920
Silk	80.200	356.000	1153.320

Table 8: https://app.worldly.io/5f29070fddc3b80009bb60e3/product-tools/msi-v2/example-materials

NB, there is no Higg MSI for cashmere, and the SAC is now called Cascale. The 4 variables that complete the MSI score are Global Warming, Eutrophication, Resource Depletion Fossil Fuels, plus a qualitative Chemistry score.

As we can see from Table 8, according to the MSI, a kilo of polyester fabric will, on average, consume 1.34 Higgies of water, emit 3.7 Higgies of CO_2e, and use up 12.1 Higgies of Fossil Fuels. An equivalent kilo of silk fabric will consume 357 Higgies of water, emit 87.4 Higgies of CO_2e, and use up 55.2 Higgies of Fossil Fuels.

Table 9: Worldly Higg MSI — Compare Materials: Polyester, Cotton, and Silk Fabric

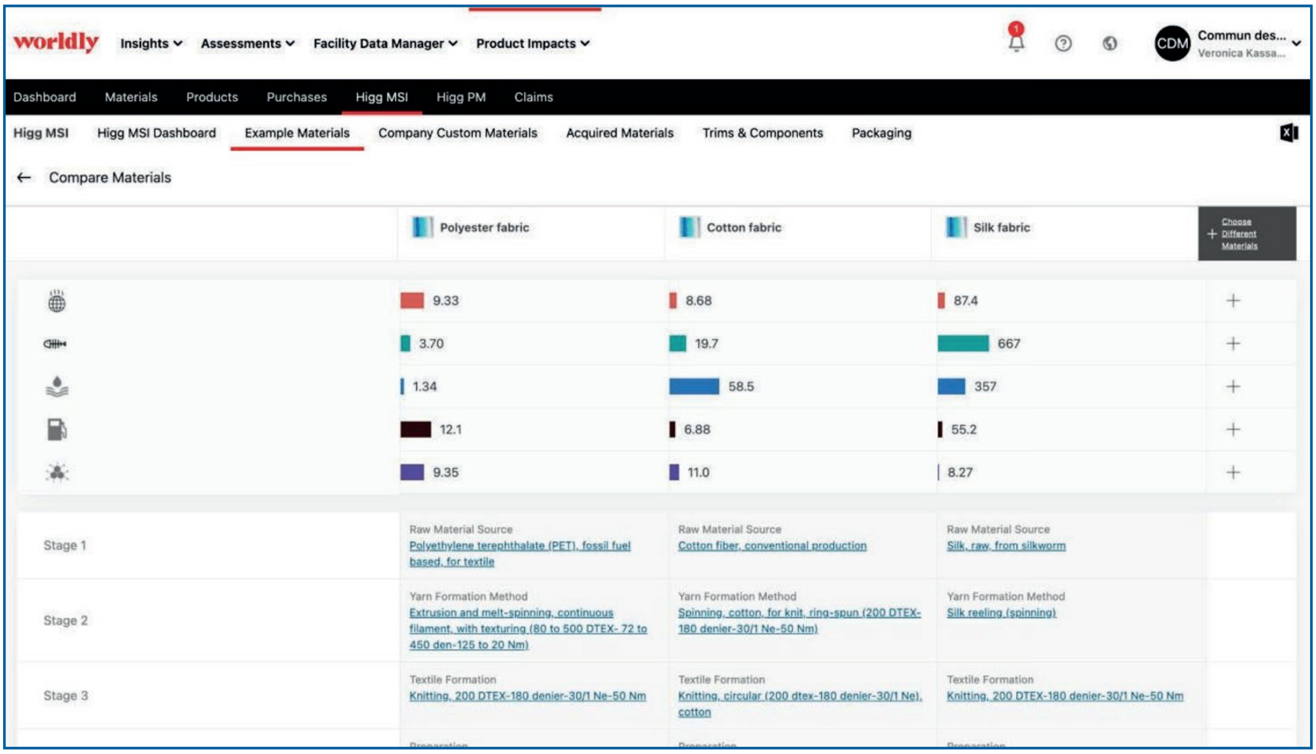
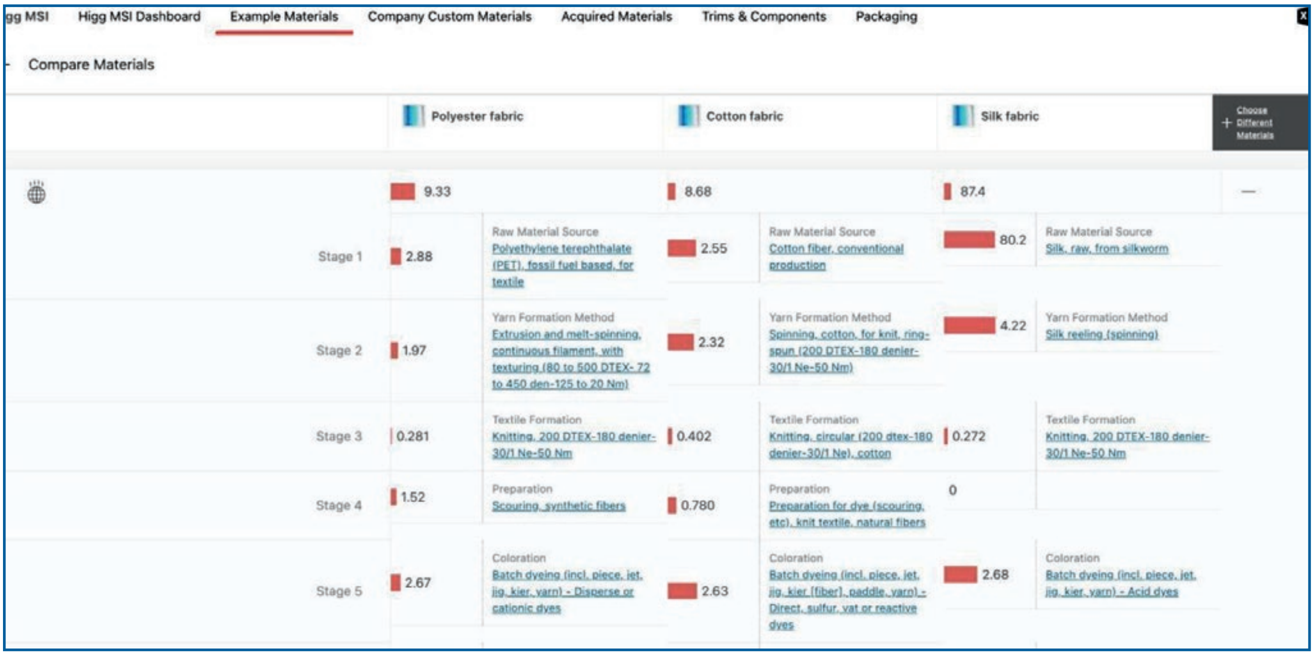


Table 9: https://app.worldly.io/5f29070fddc3b80009bb60e3/product-tools/msi-v2/example-materials/compare Screenshot taken 20/08/2025

Table 10: Worldly Higg MSI — Compare Materials: Polyester, Cotton, and Silk Fabric, Global Warming Impacts



	Polyester fabric		Cotton fabric		Silk fabric	
	9.33		8.68		87.4	
Stage 1	2.88	Raw Material Source Polyethylene terephthalate (PET), fossil fuel based, for textile	2.55	Raw Material Source Cotton fiber, conventional production	80.2	Raw Material Source Silk, raw, from silkworm
Stage 2	1.97	Yarn Formation Method Extrusion and melt-spinning, continuous filament, with texturing (80 to 500 DTEX- 72 to 450 den-125 to 20 Nm)	2.32	Yarn Formation Method Spinning, cotton, for knit, ring-spun (200 DTEX-180 denier-30/1 Ne-50 Nm)	4.22	Yarn Formation Method Silk reeling (spinning)
Stage 3	0.281	Textile Formation Knitting, 200 DTEX-180 denier-30/1 Ne-50 Nm	0.402	Textile Formation Knitting, circular (200 dtex-180 denier-30/1 Ne), cotton	0.272	Textile Formation Knitting, 200 DTEX-180 denier-30/1 Ne-50 Nm
Stage 4	1.52	Preparation Scouring, synthetic fibers	0.780	Preparation Preparation for dye (scouring, etc), knit textile, natural fibers	0	
Stage 5	2.67	Coloration Batch dyeing (incl. piece, jet, jig, kier, yarn) - Disperse or cationic dyes	2.63	Coloration Batch dyeing (incl. piece, jet, jig, kier (fiber), paddle, yarn) - Direct, sulfur, vat or reactive dyes	2.68	Coloration Batch dyeing (incl. piece, jet, jig, kier, yarn) - Acid dyes

Table 10: https://app.worldly.io/5f29070fddc3b80009bb60e3/product-tools/msi-v2/example-materials/compare Screenshot taken 20/08/2025

For the past decade, the sustainable apparel community has not only accepted these extraordinary impact claims as gospel. It has even made up justifications to explain them. One such fantastical assertion is that silk has a high carbon and fossil fuel impact because " Where silk causes the most environmental damage is in energy usage. Silk farms are kept at a certain humidity and temperature (65 degrees). Because most silk is made in hot climates in Asia, this requires a large amount of energy for air conditioning and humidity control." [1]

How this sustainability expert imagines China produced silk in the millennia before air conditioning and humidifiers were invented is unclear. In reality, if you keep silkworms at 65 °C, you will probably kill them. [2]

Please note, as part of the ROR process, prior to publication of this paper, Cascale pointed out (see Annex 1 for full details) that they had finally updated the Higg MSI polyester score. But when they state, "it is accurate to say that we have used this dataset in the past, this is out of date and no longer correct". They mean that although critics had pointed out that the LCA was outdated and unrepresentative since at least 2020, [3] Cascale had continued to use it up until days earlier. The revision is so recent (March 1, 2026) that as we were going to press, the MSI change log still had not been updated to reflect it. [4]

As a result of this update, and for what it's worth, the total Higg MSI raw material impact of Polyethylene terephthalate (PET), fossil fuel based, for textiles has increased by 27% to 15.187. This is principally attributable to an increase in the warming impact from 2.88 to 4.19, reflecting the introduction of China-specific data. [5]

Returning to the PEF, for which the polyester data has yet to be revised (and we understand that the Sphera modifications are not PEF compliant, so cannot and will not be used) for those who may be wondering, and as illustrated by Figure 25, all else constant, swapping the fiber to an organic alternative increases the total impact of a cotton tee from 38.1 to 40.3. And yes, the PEF claims like for like, organic cotton emits more carbon than polyester.

[1] https://ecocult.com/why-does-silk-have-such-a-bad-environmental-rap/
[2] https://www.veronicabateskassatly.com/read/silk-revisited
[3] https://www.veronicabateskassatly.com/read/was-it-polyester-all-along
[4] https://howtohigg.cascale.org/higg-index-tools/higg-product-tools/higg-msi/dive-deeper/higg-msi-change-log/
[5] https://lcadatabase.sphera.com/2026/xml-data/processes/110f6ff8-6063-4a61-8403-23c927236cdb.xml

Figure 25: EU PEF Organic Cotton (Traceability Simulation)

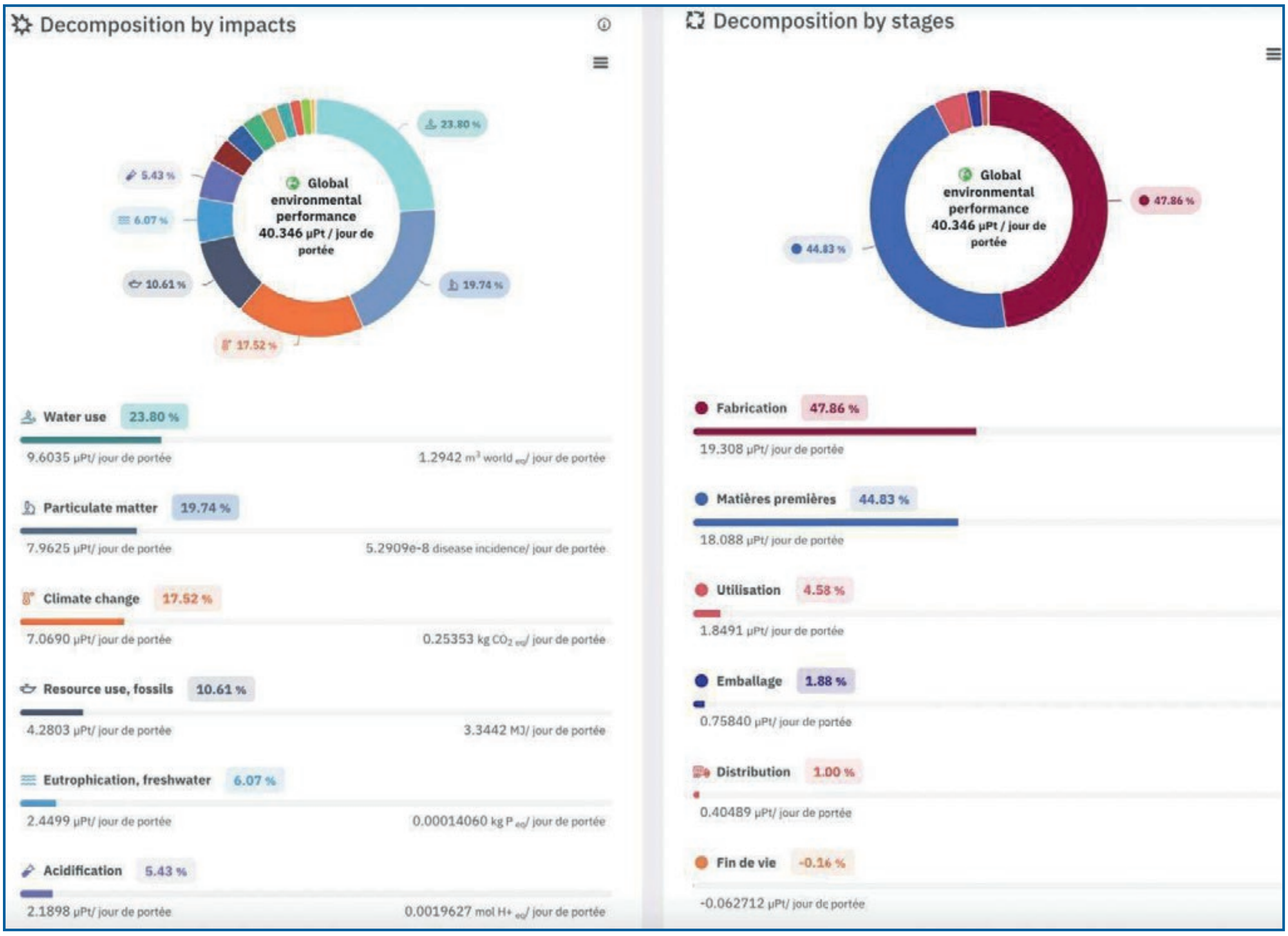


Figure 25: https://tool.glimpact.com/ecodesign/6873/11393/results Screenshot taken 05/08/2025

If and when the PEF is implemented, unless the methodology is modified, Textile Exchange and its many members will no longer be able to claim organic cotton as the preferred alternative. As we have seen, Ademe/Ecobalyse is aware of this and has attempted to correct the French PEF by increasing the weighting of ETF to the detriment of 86% of French farmers. The EU PEF TAB is also considering manipulating weightings to compensate for this fundamental flaw of LCA evaluation as currently practiced. This manipulation will disadvantage the ≈93% of EU farmers who do not practice organic cultivation. (1)

How all this is supposed to play out is anybody's guess. In their North American marketing, using the MSI, companies will presumably claim that they secured significant impact savings by switching to recycled bottle polyester and organic cotton. In their European marketing, using one of the PEF databases, they will likely be trumpeting Brazilian cotton, or, for France, domestically produced wool. While many private 'sustainability' providers - Compare Ethics in the UK, for example, (2) - don't even state where their base data is coming from.

We do not view any of these numbers and the associated claims as robust. As we have pointed out, even in the simplest cases, attempting to attribute impacts to specific areas or products is subject to significant error. Brands using this data to report on overall impact is one thing. Attempting to apply these numbers at a product level to seduce consumers is quite another. In our opinion, it is unethical to destroy the livelihoods of some of the world's poorest - and indeed of some of the poorest communities in France and the EU - based on such uncertain science.

(1) https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Fully_organic_farms_in_the_EU#:~:text=Organic%20farms-,There%20were%20245%20000%20fully%20organic%20farms%20in%20the%20EU,%25)%20%E2%80%93%20see%20Figure%201

(2) https://www.compareethics.com/

APPENDIX 3: SUPPLEMENTARY SCREENSHOTS

Figure 26: 2024 Oil and Gas Production — 9 Largest Emitters CO_2e 100yr, before Climate Trace revision of 31 July 2025

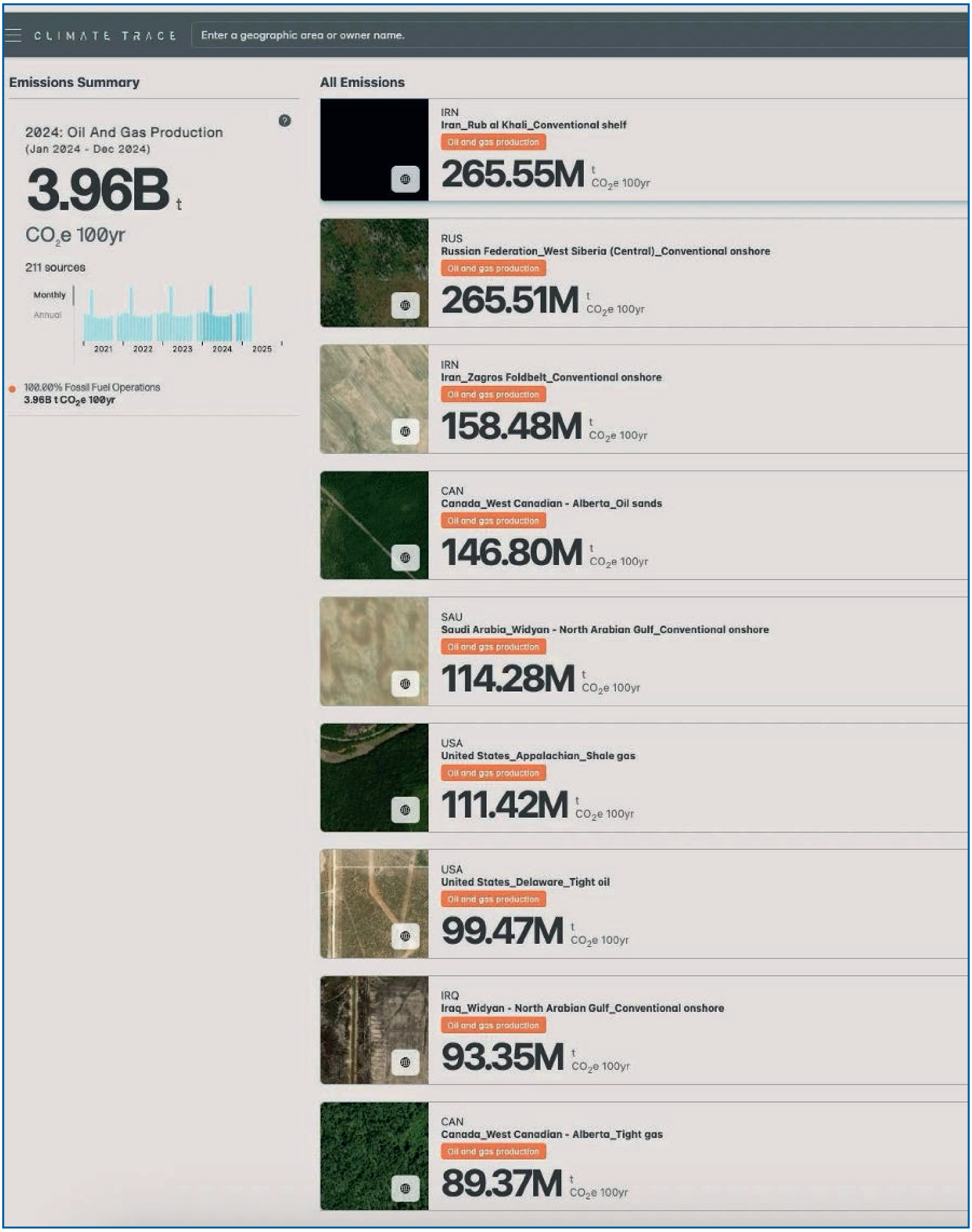


Figure 26: https://climatetrace.org/explore/#admin=&gas=co2e&year=2024&timeframe=100&sector=fossil-fuel-operations,oil-and-gas-production&asset=3588658 screenshot taken 27/07/2025

Figure 27: 2024 Oil and Gas Refinery Emissions — 8 Most Impactful Global Refineries, before Climate Trace revision of 31 July 2025 According to Climate Trace (M t CO_2e 100yr)

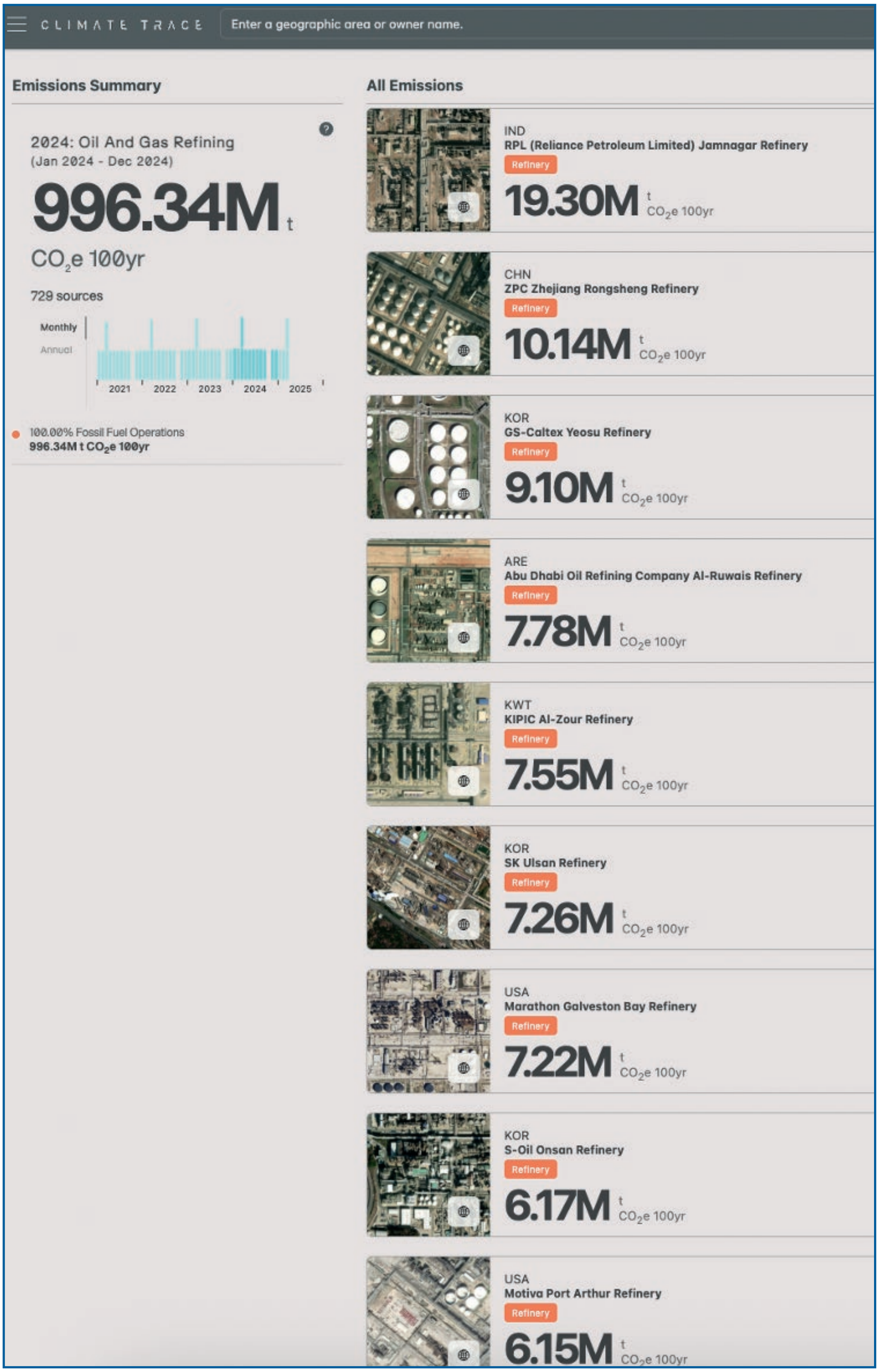


Figure 27: https://climatetrace.org/explore/#admin=&gas=co2e&year=2024&timeframe=20&sector=fossil-fuel-operations,oil-and-gas-production&asset= screenshot taken 27/07/25

Figure 28: 2024 Oil and Gas Production — 9 Largest Emitters CO_2e 100yr, after Climate Trace revision of December 2025

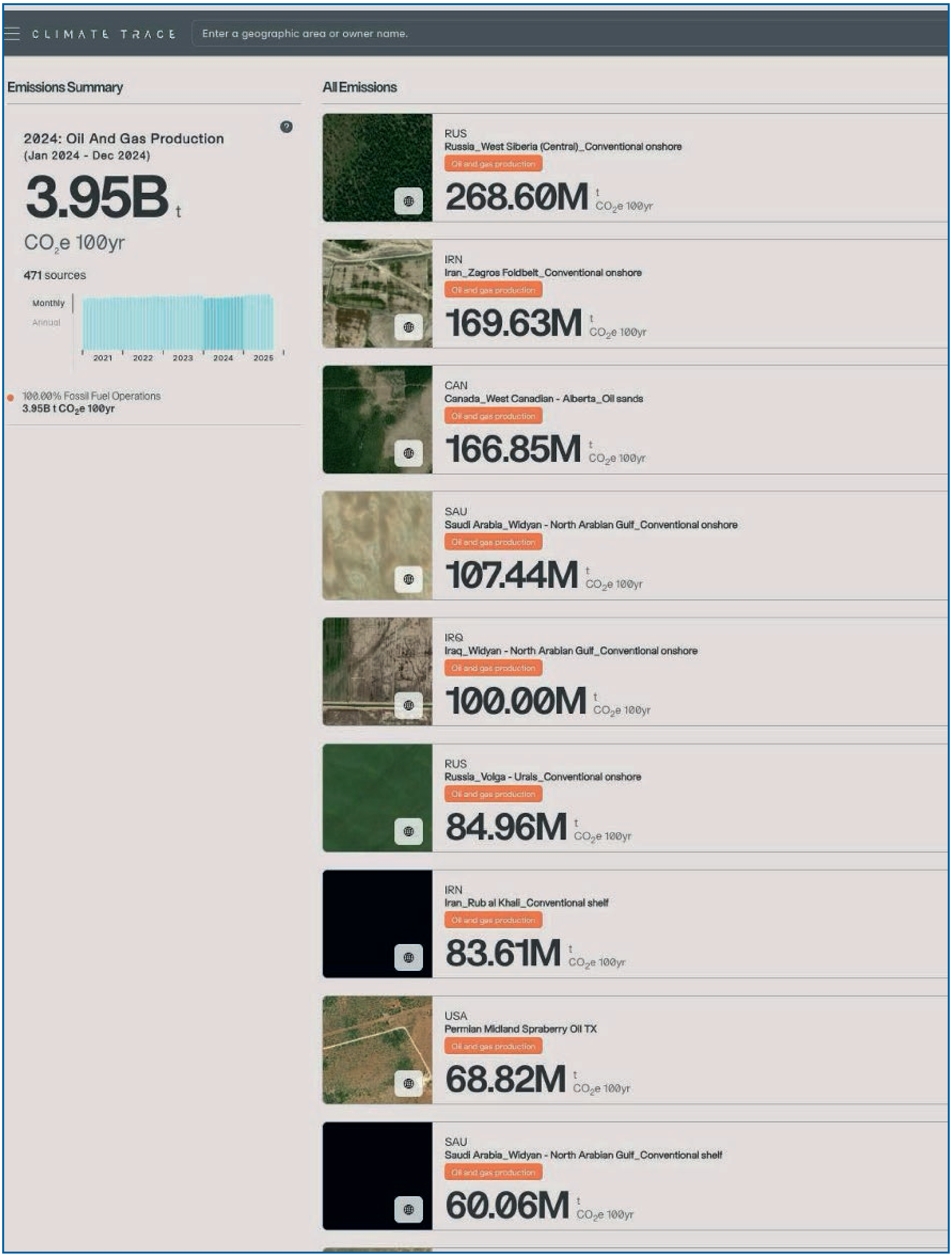


Figure 28: https://climatetrace.org/explore#admin=&gas=co2e&year=2024&timeframe=100&sector=fossil-fuel-operations,oil-and-gas-production&asset= Screenshot taken 12/12/2025

Table 11: Better Cotton Farms

Average Farm Size, Better Cotton vs Non-Better Cotton Farms									
2022/23 Season									
	National Ha	National Farmers	Better Cotton Ha	Better Cotton Farmers	Non-Better Cotton Ha	Non-Better Cotton Farmers	Better Cotton ha/farmer	Non-Better Cotton Ha/Farm	Better Cotton/Non Better Cotton Ha/Farmer
					(by subtraction)				Ratio
Australia	505,000	1,726	176,851	124	328,149	1,602	1,426	205	7.0
Brazil	1,660,000	3,263	1,322,053	366	337,947	2,897	3,612	117	31.0
China	3,100,000	8,586,200	63,617	102,772	3,036,383	8,483,428	0.6	0.4	1.7
Egypt	140,000	225,489	2,306	3,787	137,694	221,702	0.6	1	1.0
Greece	255,000	42,986	98,955	15,096	156,045	27,890	7	6	1.2
India	12,927,000	10,262,307	1,327,344	842,385	11,599,656	9,419,922	1.6	1	1.3
Israel	8,430	80	8,430	80	-	-	105		
Mali	596,000	212,564	488,957	144,845	107,043	67,719	3.4	2	2.1
Mozambique	125,000	111,945	76,352	69,488	48,648	42,457	1.1	1	1.0
Pakistan	1,800,000	1,301,000	669,317	351,062	1,130,683	949,938	1.9	1	1.6
Tajikistan				1,162					
Turkey	555,000	49,889	48,039	2,417	506,961	47,472	20	11	1.9
USA	2,950,000	8,103	231,800	332	2,718,200	7,771	698	350	2.0
Uzbekistan				5					
Total	24,621,430	20,805,552	4,514,021	1,533,921	20,107,409	19,272,798	2.94	1.04	2.82
https://icacdatabook.de.r.appspot.com/DataPortal/ChartsDetails?subGroupKey=SGK0043&chartKey=CHR0103									
https://bettercotton.org/where-is-better-cotton-grown/better-cotton-in-brazil/									

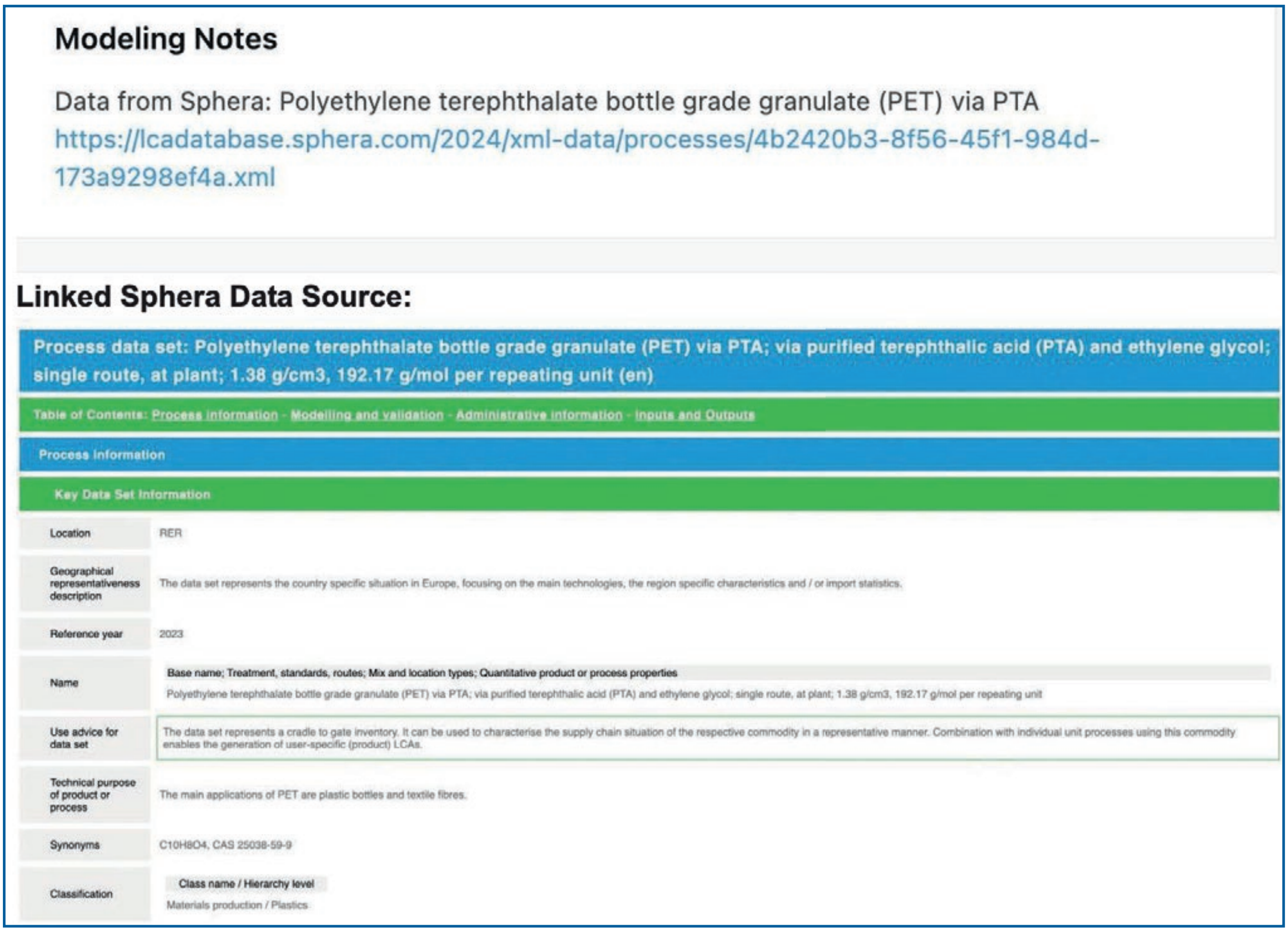
Figure 29: Who is to have Access to the EU PEF Database (Screenshot)

This report proposes a possible IT infrastructure for the EF database, which is designed to support the generation, validation, management, and distribution of EF-compliant datasets. The IT infrastructure (EF platform) will be built around three core systems:

1. Dataset Development System: this system will enable dataset generators to create, enter, and submit EF-compliant datasets. It is recommended to be a user-friendly platform that accommodates data entry in multiple formats and integrates seamlessly with existing LCA tools. The system will ensure that all datasets adhere to the requirements of the EF methods.
2. Data Management System: the data management system is a core system for data storage, organisation, integrity, maintenance, versioning control and security. This consists of many subsystems, such as the dataset validation (and data format manager), the dataset submission, the dataset reviewers management (i.e. registration of reviewers), the communication system.
3. Identity and Access Management System: this system will allow and control access to the EF platform and datasets. It will manage user roles and permissions, ensuring that only authorised individuals can submit, review, or access specific datasets. It will provide a secure means of verifying user identity and ensuring that sensitive data is protected.

Figure 29: https://op.europa.eu/en/publication-detail/-/publication/68e375bd-de4d-11ef-be2a-01aa75ed71a1Screenshot taken 01/08/25

Figure 30: Higg MSI Data Source for the Production of Virgin PET Polyester


Modeling Notes

Data from Sphera: Polyethylene terephthalate bottle grade granulate (PET) via PTA
https://lcadatabase.sphera.com/2024/xml-data/processes/4b2420b3-8f56-45f1-984d-173a9298ef4a.xml

Linked Sphera Data Source:

Process data set: Polyethylene terephthalate bottle grade granulate (PET) via PTA; via purified terephthalic acid (PTA) and ethylene glycol; single route, at plant; 1.38 g/cm3, 192.17 g/mol per repeating unit (en)

Table of Contents: Process information - Modelling and validation - Administrative information - Inputs and Outputs

Process information

Key Data Set Information

Location	RER
Geographical representativeness description	The data set represents the country specific situation in Europe, focusing on the main technologies, the region specific characteristics and / or import statistics.
Reference year	2023
Name	Base name; Treatment, standards, routes; Mix and location types; Quantitative product or process properties Polyethylene terephthalate bottle grade granulate (PET) via PTA; via purified terephthalic acid (PTA) and ethylene glycol; single route, at plant; 1.38 g/cm3, 192.17 g/mol per repeating unit
Use advice for data set	The data set represents a cradle to gate inventory. It can be used to characterise the supply chain situation of the respective commodity in a representative manner. Combination with individual unit processes using this commodity enables the generation of user-specific (product) LCAs.
Technical purpose of product or process	The main applications of PET are plastic bottles and textile fibres.
Synonyms	C10H8O4, CAS 25038-59-9
Classification	Class name / Hierarchy level Materials production / Plastics

Figure 30: https://lcadatabase.sphera.com/2024/xml-data/processes/4b2420b3-8f56-45f1-984d-173a9298ef4a.xml screenshots taken June 2025

Table 12: Comparative Quality of Polyester vs Cotton

Durability Metric	Cotton	Polyester
Tensile Strength	3–4 cN/dtex	6–7 cN/dtex
Abrasion (Martindale)	20,000 cycles	40,000+ cycles
Pilling (Washes)	15–20 washes	50+ washes
Colorfastness (UV)	ΔE > 3	ΔE < 1

Table 12: https://szoneierfabrics.com/cotton-vs-polyester/ Screenshot taken 02/08/25

Figure 31: Tongkun Industries Polyester Capacity

Figure 31: https://www.zjtkgf.com/en#:~:text=13%20million%20tons%20polymerization%20capacity,Innovation%2C%20High%2 Dprecision%20Manufacturing Screenshot taken 06/08/2025

Figure 32: Stand Earth — Links to Fracking in the Permian Basin (Coca-Cola) on the next page >>

Figure 32: Tongkun Industries Polyester Capacity

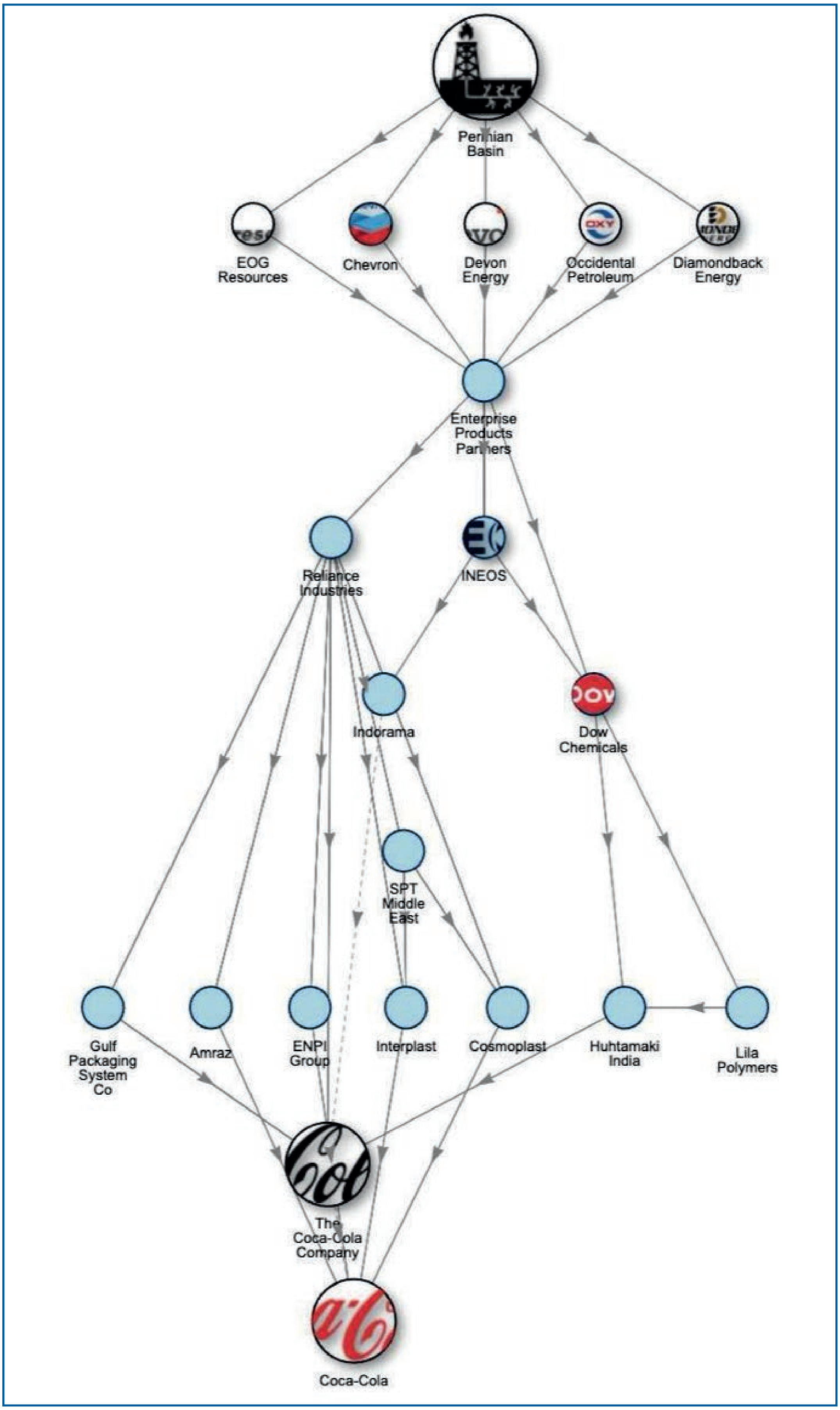


Figure 31: https://stand.earth/resources/fracked-plastics/ Screenshot taken 06/08/2025

Figure 33: Reliance Industries Exclusive Partnerships (Apparel and Footwear Brands) as of 16 March 2026

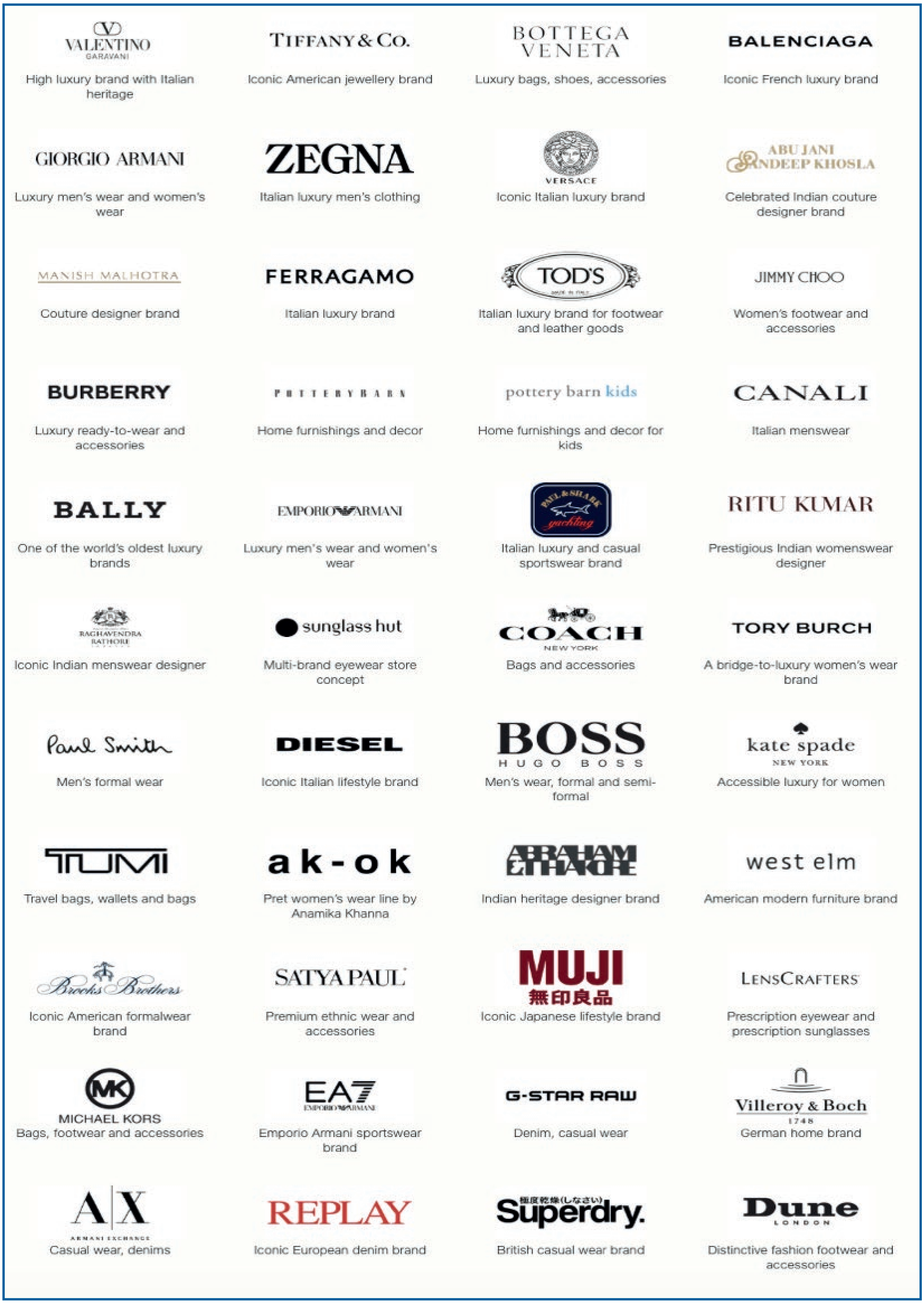


Figure 33: https://stand.earth/resources/fracked-plastics/ Screenshot taken 06/08/2025

ANNEX

ANNEX 1: STATEMENT & TECHNICAL RESPONSE TO TRACEABILITY REPORT STATEMENT FROM CASCALE

Cascale, the global nonprofit alliance empowering collaboration across the consumer goods industry, shares common ground with the report's authors on the urgent need for the fashion and apparel industry to accelerate towards a lower-impact, lower-carbon future. This imperative was clearly set out in our recent State of the Industry report, which highlights where deeper and more rapid action is required.

Where we differ, however, is in the report's assessment of the potential and appropriate application of life cycle assessment (LCA) data within standardized tools. LCAs are not a panacea, but they do have a critical role to play in assessing, measuring and improving how materials are selected and products are designed and produced. They are a powerful tool for enabling comparability and scaled decision-making across the industry, and to remain as effective as possible they need to continuously evolve and incorporate the most robust and up-to-date data available. It is therefore disappointing that much of the analysis in this report is based on out of date data and selective interpretation, leading to conclusions that are inaccurate and misleading. We have raised these inaccuracies with the authors and hope they will make the necessary revisions to ensure the accuracy of their methodology and reporting.

While material footprint analysis and traceability are essential, raw materials account for only around a quarter of the industry's overall footprint. The majority of impacts sit within Tier 2 and Tier 3 manufacturing. We absolutely agree that greater traceability and transparency are needed, but focusing disproportionately on raw materials risks overlooking the largest impact reduction opportunities. Meaningful progress towards industry targets will only be achieved if increased emphasis is also placed on all stages of the supply chain.

Ultimately, the industry must collaborate on scaled methodologies, data and systems that deliver real impact. Urgent alignment on shared objectives, and sustained investment in high-quality data and insight are essential if we are to achieve the social and environmental outcomes the industry so urgently needs.

Requested corrections

1) The report incorrectly refers to the "Worldly Higg MSI" several times throughout the document. This is incorrect framing. While available through the Worldly platform, Cascale owns and stewards the Higg MSI methodology in the same way that the European Commission owns the PEFCR methodology.

2) In Section 2. d) the report states that "The water footprint of any product is the total water involved in its production, including rainwater (green), irrigation (blue), and wastewater (grey)" and "the water footprint for cotton includes predominantly rainwater." These statements are misleading in the context of the paragraph since water consumption (and AWARE scarcity impacts) are based on blue water only. The report goes on to argue that a water footprint of 10,000L per kg of cotton is too high and would be lower if rainwater is excluded. This paragraph is misleading since rainwater is already excluded from water consumption metrics.
For example, the Higg MSI conventional cotton dataset uses a water consumption value of 2000L per kg of cotton and the dataset for Cotton Made in Africa (a program that only allows rainfed cotton) has a water consumption value of 40L per kg of cotton (coming from upstream use of water in processes such as electricity generation and fertilizer production).

3) In Section 3 the paper mentions that "a single LCA that [...] the Higg MSI [...] are all using covers European polyester production, and European production alone." This is further reiterated later on in the section and includes a link to Figure 30 in Appendix 3 showing metadata from a Sphera polyester dataset. While it is accurate to say that we have used this dataset in the past, this is out of date and no longer correct. The Higg MSI uses a polyester dataset from Sphera that represents the country specific situation of China: (1) Additionally, we have further modified this dataset to include ethylene glycol from coal as one of the feedstocks to ensure a conservative estimate for the feedstocks is used.

4) Further on in Section 3, the authors provide an incomplete timeline to Higg MSI changes with respect to polyester. It is true that the Higg MSI was updated in December 2023 to reflect the latest update on polyester from Sphera. We update our background database annually to apply the latest LCA information. This update did show a decrease in polyester's impacts due to a change by Sphera in the background dataset for a precursor material.
However, this preceded the fugitive methane emission updates by Ecoinvent and Sphera that occurred in 2024 that is referenced elsewhere in this section of the report. In October 2024 (which was the next version of the Higg MSI to feature an update to our background database) the polyester dataset in the Higg MSI was updated by Sphera to reflect the latest upstream fugitive methane emissions, specifically the venting, flaring and fugitive emissions in the crude oil and natural gas production mainly based on the methane emission factors from the IEA Methane tracker (IEA 2022) and the emissions at refineries mainly based on The European Pollutant Release and Transfer Register (EPRT-R) (EC, 2022). This resulted in an increase in polyester's GHG footprint and is aligned with the timeline of changes, for instance, of the Ecoinvent database. As previously mentioned, we have further modified the polyester dataset used in the Higg MSI to reflect the country specific situation of China, which also resulted in increases to the impacts of polyester. It is incomplete and misleading to allude to reductions of impact in the Higg MSI without this full picture.

5) The report argues against simplification of using a single score and yet continues to use this type of information as justification for their narrative. Continuing to show this type of information undermines credibility of the report, especially when portraying information in ways that are prohibited by their sources. The Higg Index Communication Guidelines are clear that a single score cannot be used and this report ignores this requirement and makes it appear as though Cascale continues to support a single score with the Higg MSI. It cannot be emphasized strongly enough that this intentional misrepresentation to make a point that is not supported by Cascale in any way.

ENDS

ANNEX 2: STATEMENT FROM TEXTILE EXCHANGE.

We appreciate the inclusion of a right-of-reply process, and we welcome constructive dialogue on the complex challenges surrounding fiber traceability and environmental impact.

We would like to provide Textile Exchange's perspective on the five "foundational claims" listed in the report:

1 "When considering toxicity, water consumption, carbon emissions, and land use, virgin polyester production has a significantly lower environmental impact than virtually all farmed fibers."

Textile Exchange fundamentally disagrees with this statement. We have consistently stated that the impact of fibers from different production systems, particularly synthetic vs. natural systems, should not be compared. Reference the Textile Exchange "Integrity in the Use of LCA" (1) document for more on this.

2 "Impacts vary little in polyester manufacturing, so a single European LCA is representative of global virgin production."

Textile Exchange fundamentally disagrees with this statement. Over the past three years, we have specifically invested in conducting an updated Polyester Life Cycle Assessment (LCA) study, which includes impact data from **geographic regions beyond Europe including** China, southeast Asia, and North America. The Polyester LCA study is anticipated to be released in 2026 and will go beyond traditional LCA methodology by using our "LCA+" approach to impact. This approach broadens the scope of assessment to include impact areas not typically covered in traditional LCA methodology, to provide a more holistic understanding of impact.

3 "Sourcing risks, arising from inadvertent use of fiber from a proscribed source - Xinjiang, for example - are high for cotton, but not for polyester."

Textile Exchange fundamentally disagrees with the implication that there are not significant sourcing risks arising from polyester. (See below for our stance on virgin polyester)

Our standards system exists to tackle sourcing risks across multiple fiber categories. They set detailed requirements for the production and primary processing of raw material, including raw recycled material, and then trace it through the supply chain from source to store.

4 "Given i) ii) and iii), to minimize risk/harmful impacts, it is vital to trace farmed fibers, which represent only c28% of the global supply. It is not necessary to trace virgin polyester, although that fiber alone represents c54% of the global total."

Textile Exchange fundamentally disagrees with this statement. We believe traceability is critical in both natural and technical production systems, which is why we offer standards that are applicable to both. In February 2026, Textile Exchange released its next set of industry targets, specifically related to sourcing from "verified best practice" production systems (2) – covering both natural and recycled systems.

(1) https://textileexchange.org/knowledge-center/reports/ensuring-integrity-in-the-use-of-life-cycle-assessment-data/

(2) https://textileexchange.org/knowledge-center/reports/preferred-production-systems-definitions-guidance/

5 "It is, in any case, impossible to trace polyester back to the oil or gas feedstock."

This is an inaccurate and misleading characterization of our stance. The exact wording used in our 2024 Materials Benchmark was: "Tracking synthetic materials back to the source of the crude oil is impossible." This statement has been taken out of necessary context, as it was published in relation to connecting the specific source of the oil through to the specific product in which that material is used. Systems to track the provenance and production practices in the oil and gas supply chain to textile and apparel products do not exist at scale today. Within recycled production, the Textile Exchange Global Recycled Standard and Recycled Claim Standard - which incorporate our Content Claims Standard - track and trace recycled feedstock from the recycler throughout the value chain. Additional developments will also ensure greater visibility of the waste collector within this value stream.

In addition to the above, we want to share directly our strategy related to polyester and organic cotton.
Approach to virgin fossil-based feedstocks Textile Exchange has stated its goal for the industry to move away from use of virgin fossil-based feedstocks as rapidly as possible. This position has been publicly stated in numerous forums, including in our 2024 "Future of Synthetics" (1) report.
We unequivocally do not condone or endorse any usage of virgin fossil-based materials and strongly advocate for phasing out virgin fossil-based synthetics as rapidly as possible, with the aim of replacing them with materials sourced from textile-to-textile recycling systems or from sustainably-sourced renewable resources. Our work within the Global Recycled Standard and the Recycled Claim Standard highlights our commitment to supporting recycling production systems. A number of recent updates to our standards system are intended to specifically enable greater transparency of textile-to-textile feedstocks to support the transition to a circular system.
Approach to organic cotton Textile Exchange promotes organic cotton as preferred due to its potential benefits for climate, nature, and people. Our approach considers impacts holistically rather than focusing solely on single metrics.
We support the continued development of impact assessment methodologies that capture a full range of impacts, including biodiversity, soil health, and livelihoods, while also supporting viable transition pathways for farmers.
Textile Exchange's Role and Our "Climate+" Approach Textile Exchange is a 501(c)(3) non-profit organization supporting the global fashion, apparel, and textile industry. A foundation of our work across reports, research, and standards is our "Climate+" approach, viewing impact holistically across climate, nature, people and animals rather than the "carbon tunnel vision" that can occur when looking at greenhouse gas emissions alone.
We appreciate the opportunity to provide these clarifications and remain open to ongoing dialogue on advancing credible, science-based solutions for the textile industry.

International cotton interests funded this study. It is published by The Bremen Cotton Exchange. The findings and conclusions, however, are those of the authors alone and do not necessarily reflect the views of the cotton sector.

(1) https://textileexchange.org/knowledge-center/reports/the-future-of-synthetics/

VERONICA BATES KASSATLY AND TERRY TOWNSEND

Fiber Traceability - a Vehicle to Ensure Sustainability or Injustice?

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