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The Myth of Chemical Recycling for Textiles

Executive Summary

In 2024 California enacted the Responsible Textile Recovery Act, the first legislation of its kind in the United States, to establish producer responsibility for post-consumer textiles. The law requires apparel producers to join or form Producer Responsibility Organizations (PROs), pay fees that fund statewide collection and sorting infrastructure, and support programs for reuse, repair, resale, recycling, and public education. It also mandates transparent reporting to ensure accountability and measurable progress over time.

This legislation is an important step forward in how we manage and think about textile waste. That said, it does not yet address some of the upstream changes needed to create a truly circular, low-carbon textile economy – like designing products for their end of life (i.e., durable use and repair), phasing out hazardous additives, reducing overall textile production, and prioritizing regenerative, non-petroleum-based fibers. These gaps leave room for compliance pathways that focus more on managing harmful waste after the fact than preventing it in the first place.

This is where technologies marketed as “chemical,” “advanced,” “molecular,” or “tertiary” recycling enter the conversation. Some industry groups increasingly promote these technologies as the solution for managing synthetic and blended textiles. By suggesting that these thermal and chemical processes can turn complex waste fiber blends into high-quality new materials, companies create the appearance of a workable circular system – even though these claims continue to be largely unproven at a commercial scale.

In practice, chemical recycling remains technologically limited, capital-intensive, and environmentally burdensome. Current processes frequently fail to achieve true material circularity, instead downcycling textiles into lower-value products and generating secondary pollutants and carbon emissions. Reliance on this approach allows producers to continue manufacturing high volumes of synthetic, petroleum-based textiles under the guise of sustainability, thereby perpetuating overproduction and dependency on fossil fuel–derived materials – ultimately reinforcing the very issues the Extended Producer Responsibility (EPR) law seeks to reform.

Why "Circular Fashion" Isn't Always Circular

Companies often use terms like *circular*, *closed-loop*, or *infinite recycling* to make their products sound more sustainable – but these usually describe an idea, not a working system. True circularity would mean ensuring that textile production volumes respect our planetary boundaries and that textile design supports safe use, reuse, recycling, and end of life, keeping clothing in use for as long as possible through repair and other refurbishment to enable reuse (e.g., re-dyeing, tailoring, upcycling, or remanufacturing). Once all reuse opportunities have been exhausted, including recycling, it would mean ensuring that the material can safely return to Earth's nutrient cycles through composting. Instead, most so-called circular systems depend on the continued overproduction and use of fossil fuel–based synthetics, harmful chemicals, and polluting recycling and disposal methods.

Without strict universal standards for measuring circularity, companies can make sweeping claims with little proof or accountability. They may highlight the recycled content in a garment while ignoring the larger environmental costs: the energy required for recycling, the chemical pollutants involved, the communities negatively affected, or the microplastics released along the way. This lack of clarity becomes especially consequential under EPR, wherein the very definition of *recycling* shapes how producers comply and what impacts are considered acceptable.

Why Recycling Clothes Rarely Works

The Limits of Mechanical Recycling

Today the majority of textile recycling is achieved through mechanical recycling processes, wherein both pre- and post-consumer garments are shredded into fibers that can be respun into new yarns. This approach is technically viable primarily for textiles composed of a single homogeneous fiber type, such as 100 percent cotton or wool.

However, the modern apparel market is dominated by fiber blends – combinations like cotton-polyester, nylon-spandex, or wool-acrylic – which present substantial challenges to mechanical recycling systems. These composite fabrics are difficult – often impossible – to separate into their original material components, and sorting remains largely manual, time-intensive, and prone to contamination. Even when the sorting process is successful, the recovered fibers are typically shorter, weaker, and of reduced quality, limiting their reuse in high-value textile applications. Consequently, most mechanically recycled textiles are downcycled into products like insulation, industrial rags, or stuffing, rather than being transformed back into new garments – the central promise of textile circularity (Schmidt et al., 2016).

Beyond material degradation, mechanical recycling does not address the pervasive issue of microplastic pollution associated with synthetic fibers. Polyester, nylon, and similar materials release microplastics at every stage of their life cycle – during wear, laundering, shredding, and reprocessing. These microscopic particles are persistent pollutants, dispersing through air, soil, and waterways, where they resist degradation and accumulate across ecosystems. Importantly, research shows that garments labeled as "recycled polyester" emit more microplastics than virgin polyester during their use phase, including during washing, undermining claims of environmental benefit (Özkan & Gündoğdu, 2021; Trunk et al., 2025).

The False Promise of "Chemical Recycling"

So-called chemical recycling has been promoted by the textile industry as a next-generation solution, capable of overcoming the barriers of mechanical recycling. Also marketed as advanced, molecular, or tertiary recycling, these technologies are framed as the pathway to a circular plastics economy, promising to break polymers down to their molecular building blocks or to recover polymers from mixed materials by dissolving them in solvents.

Chemical recycling of textiles encompasses a set of thermal and chemical processes that, unlike mechanical recycling, change the fiber chemistry to some degree (polymer breakdown for subsequent reconstitution, or chemical separation of fiber polymers from other substances). Pyrolysis, gasification, and solvent-based depolymerization break down plastic polymers that make up synthetic fibers into monomers and oligomers (incomplete polymer chains). In principle, the monomers can be chemically separated from the oligomers before being reconstituted into new polymers for use in textiles or plastics, through the same energy-intensive and polluting processes that the petrochemical industry uses to make virgin plastics.

The term chemical recycling is also used to describe solvent-based purification methods, which recover polymers from mixed materials by dissolving them in chemical solvents. These solvent-based approaches are not limited to synthetic fibers; similar processes have also been applied to cellulose-based textiles, often referred to as pulping.

However, evidence that chemical recycling can deliver genuine, viable recycling in practice remains limited, particularly in the United States, where most facilities are not actually recycling plastic. The majority operate as plastic-to-fuel systems rather than plastic-to-plastic recovery, reinforcing dependence on continued plastic production and expanding fossil fuel–based fiber markets. This creates the illusion of progress while plastic waste continues to grow. Crucially, pyrolysis processes that convert plastics into fuels are not considered recycling under widely recognized laws and standards. Major regulatory authorities, including the United Nations Environment Programme and the United States Environmental Protection Agency, as well as International Organization for Standardization (ISO) standards, explicitly exclude plastic-to-fuel technologies from their definitions of recycling (Environmental Protection Agency, 2013; Recycling Partnership, 2019; Basel Convention, 2017). Instead, these practices are classified as energy recovery.

Even in cases marketed as closed-loop – plastic-to-plastic recycling – these technologies depend on high-energy inputs, complex infrastructure, and hazardous solvents, often yielding low-quality or contaminated outputs with limited potential for fiber-to-fiber recovery. The economic and environmental costs of such processes are substantial, as a recent analysis found that pyrolysis and gasification currently create ten to one hundred times higher impacts than producing virgin polymers "due to low yields of monomers suitable for repolymerization . . . and [the] high energy requirements for the conversion and subsequent upgrading processes" (Uekert et al., 2023, p. 969).

These technologies also share some of the challenges found in mechanical recycling. For instance, the recycling of polyester in polyester-cotton blends by using solvent-based purification ultimately results in polymer degradation, as recovered polyester must be subjected to melting and extrusion to produce secondary fiber. Associated physical and thermal stress causes polymer degradation (Capone et al., 2007; Ragaert

et al., 2017), which limits the number of recycling cycles (Simon & Martin, 2019; Crippa et al., 2019).

Additionally, while these technologies can handle some contaminants, they must make up less than about 20 percent of the input material. Beyond this level, process efficiency drops significantly, requiring careful monitoring and control of incoming materials to ensure compatibility with the technology (Hann & Connock, 2020).

Beyond these constraints, the inherent complexity of textile waste itself further limits the effectiveness of chemical recycling. A recent Danish study underscores the scale of this challenge, estimating that less than 2 percent of textiles are suitable for high-quality fiber-to-fiber recycling, with the majority destined for incineration or downcycling (Logan et al., 2025). This limitation can be tied directly to the material composition of textile waste. Mixed fibers do not respond uniformly to heat or solvent treatment, unlike single-source polymers, while added chemicals (e.g., dyes and pigments, crease and shrink resistance agents, oil, soil and water repellants, and stiffening agents) increase complexity.

But technical feasibility is only one dimension of the problem. Chemical recycling also poses its own set of environmental and health risks — many of which directly contradict the promise of a safer, circular system. As in mechanical recycling, extending the life cycle of plastics and textiles through chemical recycling raises concerns about the creation of new pollution pathways, particularly the release of microplastics at multiple stages of the process (Manivannan et al., 2025). Beyond microplastics, both chemical and mechanical recycling can contribute to the accumulation and recirculation of chemical contaminants in newly manufactured products (Leslie et al., 2016; Mörsen et al., 2024). These contaminants include intentionally added substances such as pigments and flame retardants, as well as unintentionally added substances, legacy pollutants, and additional chemicals introduced during textile processing and recycling (Undas et al., 2023). In the United States, these risks are compounded by the fact that most current chemical recycling facilities generate large volumes of hazardous waste and pollutants, are disproportionately sited in low-income communities and communities of color, and release air pollutants linked to cancer, reproductive harm, and developmental issues (Natural Resources Defense Council, 2022; Hipple et al., 2024).

Without a strong toxicological risk assessment framework, scaling textile recycling under today's limited and inconsistent standards risks reintroducing hazardous chemicals into consumer products and perpetuating exposure throughout supply chains, rather than genuinely reducing environmental or human health impacts. To date, no chemical recycling facility has demonstrated the ability to process post-consumer textile waste at an industrial scale without producing substantial emissions or hazardous byproducts. Without strong environmental safeguards, expanding these approaches risks trading one form of pollution for another.

The Industry's Recycling Loopholes

In most states, textile recycling is legally classified as a waste management process. Despite this, some companies attempt to obtain permits as manufacturing operations to sidestep the oversight and regulatory scrutiny that come with waste management permitting in the United States. This regulatory maneuvering highlights a critical loophole: it allows companies to present their operations as "innovative manufacturing" rather than the handling and disposal of waste, creating the appearance of environmental responsibility while avoiding accountability.

Over 99 percent of synthetic textiles, including polyester, are produced from petroleum feedstocks. The current promotion of chemical recycling is less a solution to textile waste than a strategic effort to maintain the social license for the fossil fuel–derived plastics and synthetic fiber industries.

Chemical recycling provides a narrative that textiles can be endlessly recycled to offset the known upstream harms caused by the fossil fuel and petrochemical industries. Yet current technologies face significant technical and economic limitations. While numerous start-ups operate in this space, commercial-scale chemical recycling has consistently struggled to demonstrate a viable business model. The 2024 bankruptcy of Renewcell, one of the first commercial-scale chemical recycling plants, highlights this reality (Sustainable Fashion Forum, 2024). Despite pioneering technology and high-profile investment from companies like H&M, Renewcell struggled to generate sufficient long-term market demand for its recycled pulp. This case illustrates how quickly economic projections can collapse when industry ambitions outpace infrastructure and market realities – as the fashion industry continues to prioritize cheap, fossil fuel–based textiles, leaving recycling technologies without the market support needed to succeed.

The Global Cost of Fashion's Recycling Myth

The global cost of fashion's recycling myth extends far beyond US borders, as clothing labeled "recycled" or "secondhand" in wealthy nations is often shipped overseas to countries like Ghana or Chile, where it piles up in landfills and open dumps, creating new layers of environmental and social injustice.

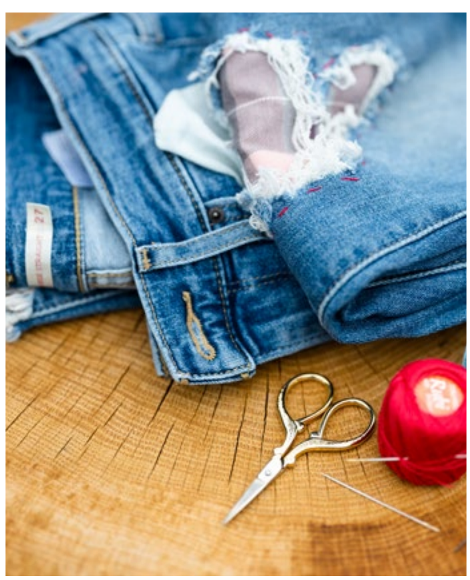
In Accra, Ghana, for instance, the Kantamanto Market receives roughly fifteen million used garments every week, the majority made of synthetic fibers (Or Foundation, 2023). Local retailers try to resell what they can, but the volume is overwhelming. Huge amounts end up in rivers, on beaches, or buried in waste heaps, where they slowly break apart into microplastics. These microscopic fibers are now found almost everywhere – from mountain snow to human bloodstreams – and synthetic clothing is a major source. The global trade in "recycled" textiles and fast fashion clothing simply shifts the pollution from one community to another, highlighting the urgent need for systemic solutions.

What Real Solutions Look Like

If California wants the Responsible Textile Recovery Act to drive true change, it must resist the temptation to treat chemical recycling as a solution. The real opportunity lies in building systems that keep clothes in circulation longer and design waste out of the process altogether.

Here is what that looks like:

1. **Repair and reuse first**. Make it easier to fix and resell clothing locally. Invest in community repair programs, tailors, and secondhand markets before investing in any new recycling technology.
2. **Design for longevity.** Encourage companies to produce garments that last longer and can be repaired, not just recycled. Simpler designs, single-fiber fabrics, and natural dyes make this possible.
3. **Use natural, regenerative fibers.** Cotton, wool, and other natural materials can be mechanically recycled into new textiles without harmful chemicals, and they biodegrade at the end of their life.
4. **Cut synthetic production.** Set clear goals to reduce the share of synthetic fibers sold in California over time. Synthetic clothing made from fossil fuels should no longer dominate the market.
5. **Protect communities.** This includes preventing the export or dumping of textile waste in Global South countries under the guise of recycling or reuse. Communities, both local and global, should not bear the environmental, health, or economic costs of overconsumption elsewhere.
6. **Require transparency across the system.** Companies should be required to disclose data on inputs, chemical use, additives, energy consumption, yields, waste, and downstream impacts. Without transparency, environmental claims cannot be verified, and safe reuse, recycling, or end-of-life pathways, including composting, are not possible.
7. **Strengthen recycling definitions.** Maintain clear recycling standards that distinguish material recycling from processes that convert textiles into fuels or energy.
8. **Track and prevent microplastic pollution.** Support research and regulations that measure how much fiber shedding occurs during washing, recycling, and waste handling – and hold producers accountable for it.
9. **Be honest in marketing.** Companies should be required to back up environmental claims with real data. Terms like green, conscious, or circular should have to be quantified as something measurable.



A Different Vision for the Future

Tackling this problem means reimagining the textile system from both ends, looking at both how materials are created and how they are designed to return to the Earth.

With so much of what we produce impossible to reclaim, the roots of the problem lie upstream. The continued dominance of complex fiber blends, especially poly-acrylic cotton, locks recyclers into chemical-intensive separation methods. And as long as those methods remain our primary option, we will not make meaningful progress on pollution tied to textile waste, regardless of how many new laws are passed.

The path forward will require moderation and simplification: producing less, blending less, and designing with recovery in mind. Without these structural shifts, and the policy tools to support them, the promise of large-scale, high-quality textile-to-textile recycling will remain out of reach.

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Acknowledgments

This white paper was authored by Alexandra Farah and Cassandra Marketos, with contributions and review by Rebecca Burgess and Sirine Rached (GAIA).

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GAIA's mission is to catalyze a global shift towards environmental justice by strengthening grassroots social movements that advance solutions to waste and pollution. We envision a just, zero waste world built on respect for ecological limits and community rights, where people are free from the burden of toxic pollution, and resources are sustainably conserved, not burned or dumped.

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