Scaling Future-Fit Materials: Market Transformation Roadmap

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About the Scaling Future Fit Materials Innovation Working Group

The Scaling Future Fit Materials working group is dedicated to advancing a future where all chemicals, materials, and products are safe, sustainable, and circular throughout their lifecycle - from creation to disposal and re-use. This group focuses on fostering innovation and promoting the adoption and scaling of sustainable materials across industries and supply chains. It serves as a collaborative platform for product manufacturers and suppliers, retailers, and material innovators to share insights, demonstrate leadership, and define actionable next steps in shaping a more sustainable and circular materials economy. The mission of the working group is to accelerate a wide-scale market transformation in support of adoption of safer, low-carbon materials and ingredients.

Sponsors

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About Change Chemistry

Change Chemistry, formerly the Green Chemistry and Commerce Council, works to accelerate the development and commercialization of innovative green and sustainable chemistry solutions in response to market, science, and policy drivers. Developing and commercializing innovative chemistry solutions and the products that incorporate them is a necessarily disruptive market process that can result in replacement of - and/or improvement on - existing chemistry. Change Chemistry's efforts to drive large scale commercial adoption of safer, sustainable and high performing chemical solutions may focus on specific functions, chemicals or classes identified by members as priorities for innovation and substitution, which may disrupt the market for incumbent chemicals. In setting priorities for its projects, Change Chemistry seeks input from its members, scientists, government authorities, and others to develop its priorities for innovation and commercialization.

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Executive Summary

Modern society—and the products and services that underpin our quality of life—are enabled by advanced chemicals and materials. From healthcare, food systems, and housing to mobility, communications, and clean energy, the chemical industry sits at the foundation of virtually every value chain in the global economy. As the global population continues to grow and emerging economies increasingly adopt higher standards of living, demand for these products and services will only accelerate.

Meeting this demand responsibly requires a deliberate shift toward materials that are not only high-performing and cost-effective, but also demonstrably safer and more sustainable over their full life cycles. This next phase of innovation calls for the development and adoption of "future-fit" materials—solutions designed to perform in a world shaped by evolving societal expectations, regulatory requirements, and environmental constraints.

While the journey toward future-fit materials often begins with new molecules and formulations, meaningful progress cannot be achieved by chemical producers alone. It is a value-chain-wide challenge—and opportunity. Brand owners, manufacturers, retailers, policymakers, investors, and other value-chain participants all extract value from existing material systems, and all play a role in shaping the conditions that enable safer and more sustainable alternatives to succeed. Advancing future-fit materials therefore requires collaboration across the entire ecosystem, from upstream innovation through downstream market adoption.

However, scaling future-fit materials is not straightforward. Beyond technical and scientific challenges, companies face significant commercial, financial, organizational, and perception-based barriers that can slow or prevent adoption. These barriers do not exist only between different nodes of the value chain; they also exist within organizations—between functions such as R&D, procurement, sustainability, finance, marketing, and executive leadership. In many cases, internal misalignment can be as limiting as external market constraints.

As a result, scaling future-fit materials cannot be achieved through isolated actions or internal optimization alone. It requires coordinated change across three interconnected dimensions: **within companies**, **across value networks**, and **through enabling market and policy conditions**. Breaking down internal silos is just as critical as aligning incentives across supply chains and engaging constructively with regulators and other stakeholders.

The *Future-Fit Materials Playbook*, developed by Sustainable Brands and Change Chemistry, is designed to support this transition. It provides practical guidance, frameworks, and real-world examples of how companies are overcoming barriers to innovation and adoption through approaches such as pre-competitive collaboration, new business and financing models, true-cost and value-based decision-making, and targeted policy engagement. The playbook is intended to help organizations move faster—together—toward material systems that are fit for the future, while continuing to deliver the products and services upon which society depends.

What are Future Fit Materials?

Building on sustainable chemistry definitions from Change Chemistry, The Expert Committee on Sustainable Chemistry, Cefic (The European Chemical Industry Council), ISC3 (International Sustainable Chemistry Collaborative Centre), UMass Lowell Center for Sustainable Production, The Stockholm University Center for Circular and Sustainable Systems (SUCCeSS), UNEP, and WBCSD, we define Future-Fit Materials as: innovative, safe, sustainable, and circular materials that allow a company to operate within planetary boundaries while meeting functional needs, effectively "future-proofing" the business against regulatory, resource, and reputation risks.

Future-Fit Materials meet or make progress in meeting the following criteria:

1. **Fit-for purpose performance:** Provide the necessary function for a specific application "without over-engineering"
2. **Safe and Sustainable by Design (SSbD)**
    a. Elimination of Harmful Substances: Free from persistent, bio-accumulative, and toxic substances
    b. Circular: Feedstocks are derived from renewable, sustainably grown, or recycled secondary raw materials rather than virgin fossil fuels. Designed to be kept in the economy through reuse, recycling, or composting.
    c. Sustainable: The value chain is net zero and nature positive.
3. **Transparency**: Health, safety, and environmental impacts of the material are traceable, verifiable, and disclosed
4. **Human Rights**: Produced in a manner that protects workers, consumers, and communities, and supports equity, justice, and fair working conditions, ensuring no burden shifting to vulnerable communities.
5. **Just Transition**: Future fit materials can be novel technologies or preferred existing materials. Transitions to novel technologies are fair and inclusive, put people at the center, create decent work opportunities, and leave no one behind.

Today's Materials Landscape

The modern economy—and the steady improvement of living standards worldwide—is built on advanced chemicals and synthetic materials that have enabled industrialization, innovation, and technological progress. As global population grows and emerging economies increasingly adopt higher standards of living, demand for materials that support health, mobility, food security, energy systems, digital infrastructure, and consumer goods will continue to rise sharply.

This growth trajectory brings with it an important responsibility: to ensure that the materials underpinning modern life can be produced, used, and cycled in ways that are safe, sustainable, and resilient over the long term. Scientists and policymakers have highlighted that the scale and pace of chemical and material innovation now challenge existing systems for risk assessment, transparency, and stewardship—particularly as production volumes accelerate globally.

Today, approximately 95% of manufactured goods rely on industrial chemical processes. Between 2000 and 2017, global chemical production doubled, and it is projected to double again by 2030 and triple by 2050. This growth reflects expanding access to modern products and services—but it also underscores the need to modernize material systems so that environmental and human health considerations advance in step with economic development.

In many markets, legacy chemical and material portfolios were optimized for cost, performance, and durability under historical assumptions. As expectations evolve, these same portfolios must now be evaluated through broader lenses—encompassing full life-cycle impacts, circularity, and long-term exposure considerations. Plastics offer a clear illustration of both the opportunity and the challenge: they deliver immense functional benefits across sectors, yet the diversity and complexity of chemical formulations used in plastics has outpaced transparency, data availability, and end-of-life solutions.

At the same time, the current materials economy leaves substantial value unrealized. Less than 10% of the more than 90 billion tonnes of materials extracted annually are cycled back into productive use. Persistent substances, while valuable for certain performance attributes, can create long-term liabilities if not designed and managed with full life-cycle considerations in mind. As a result, investors, regulators, and companies alike are increasingly focused on identifying materials that can deliver performance and durability without transferring hidden costs to society or future generations.

Crucially, these challenges cannot be solved by any single sector or actor. Chemical producers, product manufacturers, brand owners, retailers, policymakers, financiers, and technology providers all shape the material systems from which value is extracted. Advancing safer, more circular, and more sustainable materials therefore requires coordinated action across value chains—supported by shared data, aligned incentives, and new models for collaboration.

Barriers to progress extend beyond science and technology. Commercial risk, capital allocation, procurement practices, regulatory complexity, internal silos, and market perception all influence whether future-fit materials can scale. These barriers exist not only between value-chain partners, but within organizations themselves—making internal alignment as critical as external collaboration.

Together, these trends point to a material transition challenge defined not by failure, but by opportunity: an opportunity to modernize the foundations of the global economy so they remain compatible with continued growth, societal well-being, and environmental resilience. Accelerating the shift toward future-fit materials will require collective leadership, systemic thinking, and practical tools that help organizations move from intent to implementation—across companies, value chains, and markets.

The Business Case for Future-Fit Materials

The transition to future-fit materials can be a fundamental driver of long-term corporate profitability and resilience. By proactively phasing out hazardous substances, companies mitigate severe financial vulnerabilities, including the escalating threat of litigation, reputational damage, and the regulatory deselection of core product lines[1]. Beyond risk reduction, adopting these materials allows businesses to capture immense economic value, such as tapping into the estimated $100 to $125 billion market for low-carbon basic materials projected to emerge by 2030.[2] Ultimately, embracing future-fit chemistries secures a lasting competitive advantage by aligning with surging consumer demand, shielding supply chains from resource volatility, and attracting capital from institutional investors who increasingly view chemical accountability as a key indicator of financial stability and management quality.[3]

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[1] ChemSec (The International Chemical Secretariat). (2024). *A Profitable Detox: Why safer chemistry makes financial sense*.

[2] Material Economics. (2022). *Scaling Up Europe: Bringing Low-CO_2 Materials from Demonstration to Industrial Scale*.

[3] Safer Chemistry Impact Fund. (2025). *Addressing the Portfolio Risks of Chemical Hazards: Guidance for Investors*.

"The risks of inadequate chemicals management, particularly regulatory, litigation, and reputational risks, are too costly for companies and investors to ignore."[4] - Boston Common Asset Management in the 7th Annual Chemical Footprint Project Report.

Customer Demand

Sustainable materials are increasingly associated with measurable market gains. From 2015 to 2019, products marketed as using green chemistry grew 12.6 times faster than their conventional counterparts, and 5.4 times faster than the overall market.[5] The global green chemicals market is projected to reach $270 billion by 2031 with a compound annual growth rate (CAGR) of 10.77% (2024-2031),[6] while demand for low-carbon materials such as steel, chemicals, and cement could create a $100–125 billion market by 2030.

In B2B markets, sustainability is now a top three purchasing criterion. Bain's 2024 survey of 500 B2B buyers and sellers showed that nearly half of buyers report willingness to pay a 5% or greater premium, and many indicate they will leave suppliers that fail to meet sustainability expectations.[7]

Consumer attitudes reinforce this shift. Surveys show that 78% of U.S. consumers consider sustainable lifestyles important, and 71% of consumers globally factor sustainability into purchasing decisions.[8] While some says that a "value-action gap" persists between stated preferences and actual behavior, polling indicates strong public demand for safer products and stronger regulation. A 2025 study of Amazon's Climate Pledge Friendly (CPF) program found that products carrying the CPF label experienced a 12.5% increase in sales, with similar research showing revenue gains of roughly 14–15% after joining the program.[9]

Commitments from over 2,000 companies under initiatives like the *Science Based Targets* suggest that by 2030, the global market for low-carbon steel, chemicals, and cement alone will reach between $100–125 billion USD.[10] However, demand for these next-generation materials is projected to significantly outpace supply.[11] Brands that secure access to these materials now - through offtake agreements or vertical integration - will secure market share that laggards cannot access.

While cost parity is the long-term goal, current market dynamics allow for green premiums.[12] Developing markets for recycled plastics, bio-based textiles, and low-carbon metals are seeing premiums ranging from 10% to over 50% for high-quality sustainable alternatives.[13] Furthermore, products free from chemicals of concern (e.g., BPA-free, PFAS-free) offer distinct marketing advantages and deeper consumer trust.[14] Sustainable materials can command significant price premiums - recycled plastics often trade 50–100% above virgin benchmarks, and green steel 10–25% higher[15] - while long-term adoption can reduce cost volatility and lower cost of goods sold.[16]

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[4] Clean Production Action. (2024). *7th Chemical Footprint Project Report*.

[5] Sustainable Chemistry Finance Coalition. (2023). *The Investment Case for Sustainable Chemistry*.

[6] Safer Chemistry Impact Fund. (2025). *Addressing the Portfolio Risks of Chemical Hazards: Guidance for Investors*.

[7] Bain & Company. (2024). *How to Master the Art of Selling Sustainability*.

[8] Proserpio, D., Goli, A., Mangini, T., Lau, K., Yu, D. (2025). *The impact of sustainability programs on consumer purchase behavior: Evidence from Amazon*. International Journal of Research in Marketing.

[9] Ibid.

[10] Material Economics. (2022). *Scaling Up Europe: Bringing Low-CO_2 Materials from Demonstration to Industrial Scale*.

[11] Ibid.

[12] Boston Consulting Group (BCG), Fashion for Good. (2025). *Scaling Next-Gen Materials in Fashion: An Executive Guide*.

[13] Material Economics. (2022). *Scaling Up Europe: Bringing Low-CO_2 Materials from Demonstration to Industrial Scale*.

[14] University of Massachusetts Lowell - Lowell Center for Sustainable Production, Sustainable Chemistry Catalyst, Investor Environmental Health Network, Clean Production Action. (2023). *Overview: Key Actors Influencing Investments in Sustainable Chemistry* (V. 1).

[15] Material Economics. (2022). *Scaling Up Europe: Bringing Low-CO_2 Materials from Demonstration to Industrial Scale*.

[16] Boston Consulting Group (BCG), Fashion for Good. (2025). *Scaling Next-Gen Materials in Fashion: An Executive Guide*.

Improved Reputation

OECD research finds widespread awareness of chemical hazards, strong concern about chronic health and environmental impacts, and overwhelming support - over 80% - for stronger government and industry action.[17] Many people already try to limit exposure yet still perceive high residual risk, underscoring the limits of downstream controls and the need for upstream material redesign. Younger populations report higher perceived exposure, suggesting demand for safer materials will intensify.[18]

A 2022 poll conducted by the University of California of 1,200 registered US voters found that 92% of voters agree and 63% of voters strongly agree that the government should require products be proven safe before companies are allowed to put them on the market. The same study also found that 93% of voters agree and 62% strongly agree that companies should do a better job of removing harmful chemicals from consumer products. Large majorities support reducing plastics, strengthening chemical laws, and removing harmful substances even if costs increase.[19]

Regulatory Pre-Emption

The regulatory environment for chemicals and materials is shifting from reactive restriction to proactive prevention.[20] Governments globally, led by the EU's *Chemicals Strategy for Sustainability*, are implementing frameworks to phase out "substances of concern" and penalize linear waste.[21]

Cefic, the EU trade group for chemicals, estimates that 12-42% of the chemical industry's product portfolio could be restricted as new EU laws are phased in between 2023 and 2040.[22] A 2023 survey by the American Chemistry Council found that "chemical manufacturers are anticipating growing regulatory challenges" and believe themselves to be in an "increasingly unfavorable business environment".[23]

Companies relying on hazardous incumbents face "deselection risk," where core products may be banned or restricted from key markets.[24] For example, the imminent restrictions on per- and polyfluoroalkyl substances (PFAS) are forcing rapid reformulation in sectors ranging from textiles to electronics.[25, 26] Transitioning to safer alternatives now future-proofs portfolios against these inevitable policy shifts. The 2023 Integrated Report from AGC, one of the world's largest PFAS producers, identifies a risk to their division producing fluorochemical products, namely the "trend toward the stricter regulation of fluorochemicals". The company, therefore, considers it one of its main tasks to "develop products and process technologies in anticipation of environmental regulations and turn them into business opportunities"[27]

Liability Reduction

Litigation related to hazardous chemicals such as PFAS has cost companies billions, with more than 10,000 PFAS complaints filed across industries and billions in settlements.[28] Firms like Bayer and 3M have faced substantial

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[17] OECD (2024), Insights on "Attitudes towards chemicals": From the Surveys on Willingness-to-Pay to Avoid Negative Chemicals-Related Health Impacts (SWACHE) Project.

[18] Ibid.

[19] Program on Reproductive Health and the Environment. (2022). Public Opinion on Chemicals 2022.

[20] ChemSec (The International Chemical Secretariat). (2024). *A Profitable Detox: Why safer chemistry makes financial sense*.

[21] ChemSec (The International Chemical Secretariat), Economics for the Environment. (2022). *Unlock the market - Economic incentives for alternatives to hazardous chemicals*.

[22] Cefic. (2021). *Economic Analysis of the Impacts of the Chemicals Strategy for Sustainability - Phase 1 Report*.

[23] American Chemistry Council. (2023, September 6). *Survey: Chemical Producers Concerned About Challenging Regulatory and Economic Environment.*

[24] ChemSec (The International Chemical Secretariat). (2024). *A Profitable Detox: Why safer chemistry makes financial sense*.

[25] Ibid.

[26] ZDHC Foundation, Quantis. (2025). *Protecting Supply Chains and Natural Capital: The Power of Safer Chemistry*.

[27] AGC. (2023). AGC Integrated Report 2023.

[28] ChemSec (The International Chemical Secretariat). (2024). *A Profitable Detox: Why safer chemistry makes financial sense*.

legal payouts. Bayer spent €13 billion on litigation expenses between 2019 and 2023 (more than dividends over the same time period), with its CEO citing litigation as one of his top priorities of 2024.[29] Litigation related to PFAS pollution has cost 3M $10.3bn in the U.S. and the company continues to face legal challenges related to PFAS contamination in various jurisdictions, including Europe.[30, 31] As regulation tightens globally and policymakers shift toward precautionary approaches, companies reliant on hazardous substances face deselection, reformulation costs, and stranded assets.[32]

Compounding these financial threats, insurers are increasingly inserting explicit PFAS exclusions into their policies, forcing companies to shoulder these massive legal and remediation costs directly and raising the risk of sector-wide bankruptcies.[33] Looking ahead, the scale of potential liability is staggering; risk modeling firms estimate that U.S. clean-up and bodily injury costs for the largest publicly traded chemical companies could reach up to $248 billion and $66 billion, respectively.[34]

Investor Pressure

Investors are increasingly attentive: in 2025, 43 investors with over $4 trillion in assets called on chemical companies to phase out highly hazardous chemicals and transition to safer alternatives to protect biodiversity and human health.[35] "Investors are paying closer attention to how companies manage chemical risks in their supply chains," said Bill Walsh, Director of the Safer Chemistry Impact Fund.[36]

To coordinate this growing pressure, groups like the Investor Initiative on Hazardous Chemicals (IIHC) have rapidly expanded, uniting 80 institutional members representing $23 trillion in assets under management to actively engage with the world's largest chemical producers.[37] Consequently, effectively managing and disclosing chemical hazards is no longer viewed merely as a compliance issue or an ESG reporting exercise, but as a strategic imperative that is fundamentally changing the nature of investor due diligence and portfolio risk management.[38] Sustainable chemistry leadership is associated with stronger total shareholder returns, improved access to capital, and reduced long-term regulatory, reputational, and operational risk.[39]

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[29] Planet Tracker. (2024, September). *Novel Entities: A Financial Time Bomb - Why investors need to be aware of the risks and impacts of toxic artificial chemicals*.

[30] Planet Tracker. (2025). *Toxic Additives: Analysing Product Portfolio Risk*. (Wielechowski, R., & Grassi, F.).

[31] The Guardian. (22 June, 2023). *3M pays $10.3bn to settle water pollution suit over 'forever chemicals'*.

[32] ChemSec (The International Chemical Secretariat). (2023). *The Investor's Guide to Hazardous Chemicals*.

[33] ChemSec (The International Chemical Secretariat). (2024). *A Profitable Detox: Why safer chemistry makes financial sense*.

[34] Ibid.

[35] Planet Tracker. (26 June 2025). *Investors press for global action on toxic chemicals as pollution crisis escalates - Call to phase out highly hazardous chemicals aligns with biodiversity and health goals of UN Global Framework*.

[36] ChemFORWARD. (2025). *2025 Beauty & Personal Care Ingredient Intelligence Report: Clean Beauty, Quantified - Measuring Progress Towards a Safer Industry*.

[37] Investor Initiative on Hazardous Chemicals (IIHC). (2025). *2025 Progress Report*.

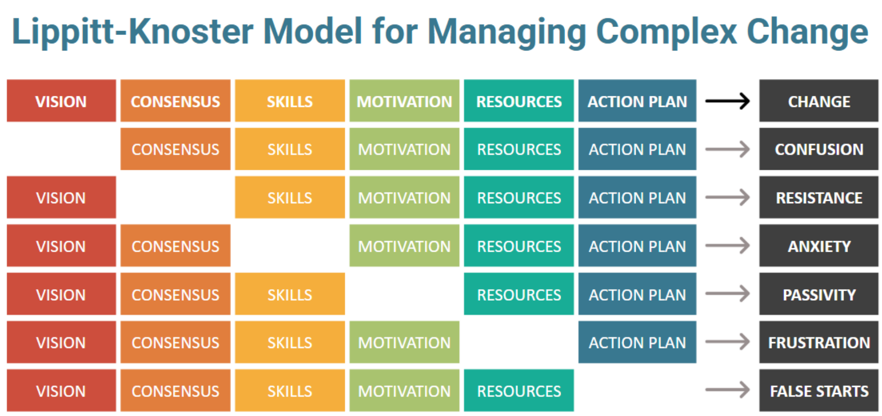
[38] Safer Chemistry Impact Fund. (2025). *Addressing the Portfolio Risks of Chemical Hazards: Guidance for Investors*.

[39] ChemSec (The International Chemical Secretariat). (2025). *6 ways to future-proof your business and stay ahead of the (chemical) curve*.

Barriers to Scaling Future-Fit Materials

The transition won't be easy. Despite accelerating pressure from markets, regulators, and investors, scaling future-fit materials is structurally complex.[40] The global chemicals and materials system is highly optimized, capital-intensive, and deeply embedded across horizontal and vertical supply chains.[41] Decades of investment in fossil-based feedstocks, specialized infrastructure, performance standards, and global trade networks have entrenched incumbent chemistries. These systems are efficient, depreciated, and institutionally reinforced.[42] Replacing them requires coordinated transformation across brands, suppliers, manufacturers, financiers, and policymakers - far beyond simple one-for-one substitution.[43, 44]

The Lippitt-Knoster Model for Managing Complex Change highlights the components required for successful transformation: vision, consensus, skills, incentives, resources, and a clear action plan. Gaps in any of these



elements produce friction.[45]

[40] European Union. (2018). *Chemicals innovation action agenda for the Transition to Safer Chemicals and Technologies*.
[41] Planet Tracker. (2025, May). *Lessons in Chemistry: Climate Action Giants*.
[42] Tickner, Joel. (2024, February 16). *Making Chemistry Safer Is Worth the Price Tag.* Scientific American.
[43] ChemSec (The International Chemical Secretariat), Economics for the Environment. (2022). *Unlock the market - Economic incentives for alternatives to hazardous chemicals*.
[44] US Department of Energy. (2025). *Scaling Sustainable Chemistry for an Industrial Transformation Forum and Roundtable*.
[45] Adapted from Lippitt, M. (1987). The Managing Complex Change Model.

Applying this framework to the challenge of scaling future-fit, sustainable materials reveal a system constrained at nearly every dimension.

Vision	Consensus	Skills	Motivation & Incentives	Resources	Action Plan
Inconsistent definitions and fragmented standards Inconsistent evaluation metrics Ambiguous performance expectations	Misaligned priorities Siloed decision making Opaque supply chains Information blocking	Workforce skill gaps Assessment complexity Performance trade-offs Scale-up difficulties:	The incumbency advantage Risk aversion Regulatory uncertainty, volatility, and fragmentation Externalities not priced	The funding "Valley of Death" Infrastructure gaps Feedstock shortages Lack of drop-in solutions Data scarcity	Approval delays Policy disconnect Lack of internal roadmaps

Vision

Transformation requires a shared understanding of the destination. Today's materials transition is hindered by persistent ambiguity in definitions, metrics, and performance expectations.

- **Inconsistent definitions and fragmented standards:** There is no universally accepted definition of "sustainable chemistry," resulting in inconsistent claims about what qualifies as "safer" or "eco-innovative" (GAO, 2018; Wood & Lowell Center for Sustainable Production, 2019).
- **Inconsistent Evaluation Metrics:** Companies and industries lack a common language or standardized protocols for critical evaluation methods like Life Cycle Assessments (LCA) and Techno-Economic Analyses (TEA). This inconsistency makes it difficult for decision-makers and purchasers to accurately compare the sustainability of one product against another (U.S. Department of Energy, 2021, Sustainable Chemistry in Manufacturing Roundtable Report).
- **Ambiguous performance expectations**: Unclear or overly rigid performance standards often evaluate new materials against a single "best in class" metric based on incumbent technologies, failing to recognize alternatives that are sufficiently "fit-for-purpose" for specific applications. This ambiguity and overprescription of requirements can blind decision-makers to viable, safer innovations and cause them to incorrectly conclude that no functional alternatives exist.

Consensus

Scaling sustainable materials demand coordinated action across complex global value chains. Yet the current ecosystem is deeply fragmented.

- **Misaligned Priorities:** Different actors across the value chain lack alignment on which facets of sustainability to prioritize (e.g., carbon footprint reduction vs. circularity vs. toxicity), leading to disjointed efforts (McKinsey & Company, 2023, Sustainable packaging 2025: top barriers).
- **Siloed decision-making:** Without cross-functional collaboration spanning design, sourcing, and finance, sustainable material adoption is often treated as an isolated initiative rather than a fully integrated core business strategy. Furthermore, different business units often possess varying levels of expertise and unique sustainability measurement needs, making it difficult to communicate results and make cohesive, company-wide material selections.

- **Opaque Supply Chains:** Demand signals from retailers and brands often fail to reach upstream chemical manufacturers due to limited transparency and weak coordination mechanisms (Wood & Lowell Center for Sustainable Production, 2019).
- **Information Blocking:** Legitimate needs for transparency are often blocked by Confidential Business Information (CBI) claims, preventing the sharing of ingredient data necessary to build consensus around safe alternatives (Wood & Lowell Center for Sustainable Production, 2019, Chemicals Innovation Action Agenda).

Skills

Safe and Sustainable by Design (SSbD) innovation requires new technical capabilities that remain underdeveloped across industry. The result is institutional anxiety around change - particularly where technical risk intersects with regulatory and reputational exposure.

- **Workforce skill Gaps:** There is a documented shortage of chemists and engineers trained in green chemistry and sustainable process design, leaving companies struggling to hire the talent needed to innovate (U.S. Department of Energy, 2021, Sustainable Chemistry in Manufacturing Roundtable Report).
- **Assessment Complexity:** Evaluating alternative materials requires multidisciplinary expertise spanning toxicology, environmental science, and materials engineering. Small and medium-sized enterprises (SMEs), in particular, lack the technical capacity and personnel to evaluate hazard data, conduct pilot testing, or validate new alternatives, leading to anxiety over "regrettable substitutions" (Caldeira et al., 2023, Safe and Sustainable by Design chemicals and materials), (Wood & Lowell Center for Sustainable Production, 2019, Chemicals Innovation Action Agenda).
    - "Historically, chemical hazard assessments that indicate the human and environmental impacts associated with individual chemicals have been expensive, inconsistent across methods, and siloed within individual companies."[46]
- **Performance Trade-Offs:** Adopting new sustainable materials frequently forces companies to navigate difficult compromises between environmental benefits, overall cost, and functional efficacy. For instance, modifying material to meet necessary performance specifications might inadvertently decrease its ultimate recyclability or require the use of new additives that present their own environmental or health challenges.
- **Scale-Up Difficulties:** Transitioning novel materials from laboratory prototypes to commercial production requires immense capital expenditures that stretch company balance sheets and deter traditional private investors. This creates a funding "valley of death" where innovators struggle to finance the critical, commercially relevant piloting and demonstration facilities needed to prove the viability of their technologies.

Motivation & Incentives

Even when vision and skills are present, change falters without strong economic and strategic drivers. Current market structures favor incumbency.

- **Incumbency Advantage:** Fossil-based materials benefit from decades of optimization and fully depreciated infrastructure. Because environmental and health externalities remain largely unpriced, incumbent materials retain a structural cost advantage (Palma & Hodgett, n.d.; Wood & Lowell Center for Sustainable Production, 2019).

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[46] Safer Chemistry Impact Fund. (2024). *Accelerating the Transition to Safer Chemistry: Establishing a Collective Vision & Impact Metrics*.

- **Risk Aversion:** Reformulation introduces performance uncertainty, supply chain disruption risk, and potential consumer rejection. Manufacturers therefore default to validated materials (GAO, 2018).
- **Regulatory uncertainty, volatility, and fragmentation:** The global landscape for new chemicals and materials is plagued by varying regulatory requirements across different jurisdictions, forcing companies to engage in costly product customizations to achieve legal compliance. This fragmentation, combined with lengthy and unpredictable environmental permitting processes designed for incremental changes rather than rapid transitions, discourages the massive investments required to realize economies of scale.
- **Externalities not priced:** "Making prices reflect true social and environmental costs is essential for incentivizing innovation in green technology, including green chemistry."[47]

Resources

Motivation alone is insufficient without capital, infrastructure, and data.

- **The Funding "Valley of Death":** Bringing new materials to industrial scale requires massive Capital Expenditure (CapEx) - often stretching company balance sheets with investments in the billions. There is a lack of "patient capital" to bridge the gap between laboratory research and commercial-scale demonstration facilities (Material Economics, 2022, Scaling Up Europe), (U.S. Department of Energy, n.d., Scaling Sustainable Chemistry for an Industrial Transformation).
- **Infrastructure Gaps:** There is a severe lack of physical infrastructure, including shared pilot-testing facilities, clean energy grids, and recycling systems necessary to process circular feedstocks. Furthermore, securing a dependable, commercial-scale supply of bio-based or recycled raw materials remains highly volatile (U.S. Department of Energy, 2021, Sustainable Chemistry in Manufacturing Roundtable Report).
- **Feedstock shortage:** Feedstock shortages present a fundamental barrier to the commercial scaling of future-fit materials, as manufacturers struggle to secure reliable, commercial-scale supplies of both renewable and circular raw materials. Bio-based feedstocks are frequently constrained by seasonal variability, ethical concerns over land-use and biodiversity impacts, and fierce resource competition from the heavily subsidized bioenergy sector. Unlike fossil fuels, renewable feedstocks are subject to regional and seasonal variability, as well as extreme weather events driven by climate change.[48] Similarly, the adoption of recycled, circular feedstocks is severely bottlenecked by highly fragmented, inefficient global waste collection and sorting systems that fail to aggregate the massive, high-quality waste streams required for industrial-scale chemical recycling. Ultimately, the inability to guarantee a steady, cost-effective flow of sustainable feedstocks deters the massive capital investments required to build next-generation processing facilities, thereby keeping production volumes low, driving up "green premiums," and maintaining the industry's reliance on entrenched fossil-based incumbents. This variability makes it difficult to guarantee the highly consistent, large-scale supply of raw materials that industrial chemical manufacturers require to run their operations efficiently
- **Lack of drop-in solutions:** Many novel sustainable chemicals cannot simply be interchanged with incumbent materials, frequently requiring costly new equipment, mechanisms, and process modifications. Because these alternatives are rarely direct "drop-in" replacements, manufacturers face significant technical and financial hurdles to adapt their existing, highly optimized infrastructure to accommodate them.
- **Data Scarcity:** A pervasive lack of transparent, high-quality data regarding the toxicity, environmental fate, and performance of new chemical alternatives frustrates innovation and limits confident decision-making (Caldeira et al., 2023, Safe and Sustainable by Design chemicals and materials). A 2025 Report from the Know Better, Do Better Collaborative (an industry-led initiative managed by ChemFOWARD)

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[47] OECD. (2023). *Economic instruments to incentivise substitution of chemicals of concern – a review*.

[48] National Science and Technology Council (NSTC). (2023). *Sustainable Chemistry Report: Framing the Federal Landscape*.

found that “24% of ingredients remain uncharacterized, representing a significant blind spot for consumer safety, brand risk, and investor liability”.

Action Plan

Transformation requires coordinated execution across policy, industry, and finance. Yet roadmaps are often incomplete or misaligned. Without integrated planning, progress emerges in bursts - followed by stalls.

- **Approval Delays:** Permitting and regulatory frameworks were designed for incremental upgrades, not rapid deployment of breakthrough technologies. Approval processes are frequently lengthy, costly, and unpredictable (Material Economics, 2022).
- **Policy Disconnect:** There is a persistent lack of connection between regulatory priorities (e.g., banning a chemical) and the research and innovation funding required to actually develop a viable replacement, leading to frantic, uncoordinated scrambles for alternatives (Wood & Lowell Center for Sustainable Production, 2019, Chemicals Innovation Action Agenda).
- **Lack of internal roadmaps:** Many brands lack centralized transition strategies, internal carbon pricing, or dedicated financing mechanisms to systematically integrate next-generation materials (Fashion for Good & BCG, 2025).

Viewed through the Lippitt–Knoster lens, the challenge is not a single bottleneck but a multi-dimensional failure of alignment. The transition to future-fit materials is constrained simultaneously by unclear vision, fragmented consensus, capability gaps, weak incentives, insufficient resources, and incomplete execution frameworks. Addressing any one barrier in isolation is unlikely to unlock scale. Durable transformation requires coordinated intervention across all six dimensions of change.

Future-Fit Materials Market Transformation Roadmap

Companies cannot scale future-fit materials through internal optimization alone. They must also reshape markets and enabling conditions. **Scaling future-fit materials requires coordinated change across three interconnected spheres: within companies, across value networks (i.e., supply chains), and through the regulatory environment.** Progress in one sphere without the others results in stalled adoption, cost premiums, or stranded innovation.

Step	Company	Value Network	Policy
Measure, Disclose, & Set Targets	Publish Chemical Footprint and time-bound targets in line with the Chemical Footprint Project and IIHC Adopt a strong chemicals or materials policy and RSL / MRSL Publish a time-bound phase-out roadmap Build cross-functional teams, educate stakeholders, and articulate the business case	Align definitions, targets, and hazard and sustainability metrics across suppliers and customers Harmonize RSLs / MRSLs across suppliers and customers Empower buyers, sellers, and investors to talk about future fit materials	Support harmonized global hazard classifications Support disclosure mandates, supply chain transparency requirements, and public chemical registries Advocate for targeted chemical phase-out timelines

Design & Assess	Embed Safe and Sustainable by Design principles into stage gate processes Conduct alternatives assessments Factor externalities into ROI calculations	Standardize and communicate specs to help suppliers scale Co-develop assessment methodologies Share assessment costs and invest in shared testing infrastructure Share hazard and performance data Share R&D costs through pre-competitive and competitive collaboration	Advocate for harmonized assessment criteria Support regulatory recognition and incentivization of safer alternatives
Contract & Fund	Commit to demand Finance transition costs Adjust procurement incentives	Participate in offtake agreements Pool demand (across industries) Participate in collaborative market development Make shared infrastructure investments	Support and utilize blended finance mechanisms Advocate for transition tax credits Enable public procurement preferences

Step 1: Measure, Disclose, & Set Targets

Company

- **Publish Chemical Footprint and time-bound targets in line with the Chemical Footprint Project and IIHC:** Companies should quantitatively measure their chemical footprint to track the mass of hazardous chemicals present in their products and operations. By participating in initiatives like the Chemical Footprint Project and aligning with the Investor Initiative on Hazardous Chemicals (IIHC), businesses can set time-bound reduction goals and publicly report their progress, signaling leadership to investors and stakeholders.
- **Adopt a strong chemicals or materials policy and RSL / MRSL:** Establishing a comprehensive chemicals policy that extends beyond basic regulatory compliance is a foundational step for robust corporate chemical management. To implement this policy effectively, companies should adopt a Restricted Substances List (RSL) to restrict hazardous chemicals in finished products and a Manufacturing Restricted Substances List (MRSL) to govern chemical inputs and protect workers during production.
- **Publish a time-bound phase-out roadmap:** Businesses should develop actionable, time-bound plans to phase out products that contain highly hazardous or persistent chemicals, such as PFAS.[49] Publishing these roadmaps ensures accountability while proactively mitigating risks.
- **Build cross-functional teams, educate stakeholders, and articulate the business case:** Successful implementation of sustainable chemistry requires deep internal alignment, engaging departments ranging from procurement to product design and sustainability. Furthermore, organizations must educate their supply chains and articulate the strong financial business case for safer alternatives, highlighting long-term benefits like reduced liability and enhanced competitive advantage.

[49] ChemSec (The International Chemical Secretariat). (2024). *A Profitable Detox: Why safer chemistry makes financial sense*.

Value Network

- **Align definitions, targets, and hazard and sustainability metrics across suppliers and customers:** A fragmented understanding of sustainability criteria frequently stifles progress across the value network.[50] Collaboratively establishing standardized definitions, shared hazard criteria, and uniform sustainability metrics ensures that both upstream suppliers and downstream customers evaluate materials using a common, science-based language.[51]
- **Harmonize RSLs / MRSLs across suppliers and customers:** The proliferation of individual, brand-specific restricted substance lists creates an overwhelming compliance and reporting burden for suppliers.[52] By harmonizing RSLs through industry-wide initiatives like the ZDHC or AFIRM, value chains can send consistent demand signals and simplify the phase-out of hazardous chemistries.
- **Empower buyers, sellers, and investors to talk about future fit materials:** Bridging the communication gap between buyers and sellers is essential for advancing sustainable materials, as current interactions often lack a unified vocabulary. For example, a 2024 survey by Bain showed that while 85% of B2B sellers report that they embed some degree of sustainability in their products and services, only 27% consider themselves very knowledgeable about their customers' sustainability needs.[53] Providing shared platforms, training, and standardized data enables all stakeholders—including the financial community—to confidently discuss, evaluate, and prioritize future-fit chemistry in their purchasing and investment decisions.[54]
    - **Case Study: BASF Eco-Efficiency Analysis**

Policy

- **Support harmonized global hazard classifications:** Inconsistent hazard classifications create market confusion and hinder the global transition to safer chemistry.[55] Industry leaders should advocate for and support the widespread adoption of standardized systems, such as the UN's Globally Harmonized System of Classification and Labelling of Chemicals (GHS), to ensure chemical hazards are universally recognized and managed.[56]
- **Support disclosure mandates, supply chain transparency requirements, and public chemical registries:** The lack of transparency across complex, multi-tiered supply chains is a critical barrier to identifying and substituting hazardous substances. Advocating for policies that mandate full material disclosure and publicly accessible chemical registries helps overcome these hurdles, empowering downstream users to make informed decisions.[57]
- **Advocate for targeted chemical phase-out timelines:** Voluntary actions are often insufficient to drive rapid, sector-wide transformations. Companies should support regulatory frameworks that establish

[50] OECD. (2024). *A Landscape of Sustainability Attributes Considered by Companies During Chemical and Material Selection*.
[51] U.S. Department of Energy - Office of Energy Efficiency and Renewable Energy. (2020, November 17). *Advanced Manufacturing Office - Sustainable Chemistry in Manufacturing Processes Roundtable: Summary Report*.
[52] ChemSec (The International Chemical Secretariat). (2025, June 4). *The Textile Guide: How to replace hazardous chemicals.*
[53] Bain & Company. (2024). *How to Master the Art of Selling Sustainability*.
[54] Safer Chemistry Impact Fund. (2025). *Addressing the Portfolio Risks of Chemical Hazards: Guidance for Investors*.
[55] Safer Chemistry Impact Fund. (2024). *Accelerating the Transition to Safer Chemistry: Establishing a Collective Vision & Impact Metrics*.
[56] United Nations Environment Programme (UNEP). (2019). *Global Chemicals Outlook II – From Legacies to Innovative Solutions: Implementing the 2030 Agenda for Sustainable Development*.
[57] European Union. (2018). *Chemicals innovation action agenda for the Transition to Safer Chemicals and Technologies*.

clear, legally binding timelines for the phase-out of specific chemicals of concern, ensuring a level playing field and providing the certainty needed to justify investments in safer alternatives.[58]

Step 2: Design & Assess

Company

- **Embed Safe and Sustainable by Design principles into stage gate processes:** To avoid creating new toxic legacies, innovators must integrate Safe and Sustainable by Design (SSbD) frameworks directly into their research and development stage gates. This ensures that human health, environmental safety, and circularity are prioritized alongside cost and performance from the very inception of a new molecule or product.[59]
- **Conduct alternatives assessments:** When substituting a hazardous chemical, companies must rigorously evaluate potential replacements to avoid regrettable substitutions. Utilizing robust chemical alternatives assessment protocols helps systematically compare the hazard profiles, cost, and functional performance of various options before a final selection is made.
    - **Case Study: IFF Innovation for Sustainability (I4S) Methodology**
- **Factor externalities into ROI calculations:** Traditional return on investment (ROI) calculations often fail to account for the hidden, externalized costs of hazardous chemicals, such as worker exposure, environmental remediation, and future litigation. Forward-thinking companies should redefine economic value creation by internalizing these externalities into their financial models, making the business case for safer alternatives much clearer.[60]

Value Network

- **Standardize and communicate specs to help suppliers scale:** Suppliers face significant challenges scaling sustainable materials when buyers constantly demand highly customized formulations or blends. By standardizing fabric or material specifications and consistently communicating these needs, brands can guarantee the predictable order volumes suppliers require to optimize production and achieve economies of scale.
- **Co-develop assessment methodologies:** Evaluating complex trade-offs in sustainable chemistry requires multi-disciplinary expertise that few individual companies possess. Value network actors should collaborate to co-develop robust, science-based assessment methodologies that evaluate full lifecycle impacts, ensuring industry-wide trust and alignment.
- **Share assessment costs and invest in shared testing infrastructure:** The financial burden of toxicological screening and performance testing often stalls the adoption of new chemistries. Creating public-private incubators or pre-competitive consortia allows companies to share the costs of assessment and jointly invest in much-needed open-access piloting and demonstration facilities.
- **Share hazard and performance data:** Data scarcity regarding chemical hazards and material performance severely bottlenecks innovation. Establishing secure data-sharing platforms and chemical hazard data trusts enables value chains to quickly identify safer alternatives and close knowledge gaps without repeatedly funding redundant safety testing.
    - **Case Study: ChemForward Chemical Hazard Data Trust**
- **Share R&D costs through pre-competitive and competitive collaboration:** Developing breakthrough sustainable chemistries is highly capital-intensive and technically challenging. Companies can accelerate

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[58] OECD. (2022). *Government Risk Management Approaches Used for Chemicals Management*.

[59] Safer Chemistry Impact Fund. (2025). *Addressing the Portfolio Risks of Chemical Hazards: Guidance for Investors*.

[60] World Business Council for Sustainable Development (WBCSD), ERM. (2024). *Towards Planet Positive Chemicals: A Chemical Transformation Roadmap*.

progress by forming pre-competitive research and development consortia to pool resources, tackle shared functional challenges, and share the financial risks of early-stage innovation.

   - **Case Study: Eastman, Sealed Air, and Ahold Delhaize collaborate to launch compostable protein trays**

Policy

- **Advocate for harmonized assessment criteria:** A proliferation of varying sustainability metrics makes it difficult to accurately compare new materials and assess their true environmental benefits. Stakeholders should advocate for government and industry bodies to establish consistent, universally accepted criteria for defining and assessing what constitutes "safe and sustainable" chemistry.
- **Support regulatory recognition and incentivization of safer alternatives:** Entrenched fossil-based incumbents often maintain a significant cost advantage over sustainable novel materials. Companies must advocate for policies that formally recognize verified safer alternatives and provide targeted regulatory incentives—such as expedited permitting—to accelerate their market entry.
   - Case Study: Renewable Carbon Initiative advocacy to influence policy development in the EU

Step 3: Contract & Fund

Company

- **Commit to demand:** Securing reliable, long-term market demand is crucial for scaling novel materials out of the laboratory. Brands can demonstrate this commitment by setting public targets for sustainable material inclusion and integrating these goals directly into their core business strategies and sourcing plans.[61]
- **Finance transition costs:** Implementing safer chemistry often entails significant capital expenditures for facility upgrades and product reformulations. Companies can support this shift by establishing internal transition financing mechanisms, ensuring that product teams have the necessary capital to absorb the initial "green premiums" of novel materials.[62]
- **Adjust procurement incentives:** Procurement teams are traditionally incentivized strictly on cost-reduction, which penalizes the adoption of innovative but initially more expensive sustainable materials. Organizations must realign procurement incentives and KPIs to actively reward the sourcing of verified safer and circular chemistries.

Value Network

- **Participate in offtake agreements:** Innovators require financial certainty to secure the capital needed for building commercial-scale production facilities. Buyers can help bridge this funding gap by signing binding offtake agreements or letters of intent, effectively guaranteeing a future market for the sustainable chemicals once produced.[63]
- **Pool demand (across industries):** Individual companies rarely generate enough demand volume on their own to justify a supplier's massive transition to a new sustainable chemical. By participating in cross-

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[61] Boston Consulting Group (BCG), Fashion for Good. (2025). *Scaling Next-Gen Materials in Fashion: An Executive Guide*.
[62] University of Massachusetts Lowell - Lowell Center for Sustainable Production. (2022, October). *Analyzing Success Factors to Accelerate Commercialization of New Technologies that Replace Incumbents: Lessons for Green Chemistry Commercialization*.
[63] Sustainable Chemistry Finance Coalition. (2023). *Strategic approach to transition finance for sustainable chemicals and materials: A blueprint for the finance community.*

industry consortia to pool demand, multiple brands can aggregate their purchasing power to signal a massive, unified market need that accelerates commercial production.

- **Participate in collaborative market development:** Engaging in collaborative market development initiatives connects startups with established supply chains and fosters an ecosystem primed for large-scale commercialization. Companies can work together to give emerging technologies the ability to enter the market via a niche (high margin, low volume) application and work with value chains to map out a scalable growth strategy that seeks to tackle new market segments on an incremental (in volume requirements) basis.
    - **Case Study:** L'Oréal sustainable innovation "L'AcceleratOR"
- **Make shared infrastructure investments:** The lack of specialized physical infrastructure, such as commercial-scale biorefineries or advanced recycling facilities, severely restricts the supply of future-fit materials. Value chain actors should collaborate to finance shared, decentralized production infrastructure or jointly fund the repurposing of existing legacy chemical plants.

Policy

- **Support and utilize blended finance mechanisms:** The high risk and extended timelines associated with scaling physical chemical technologies often deter conventional private equity. Blended finance mechanisms that combine public grants, philanthropic capital, and private investment can effectively de-risk these projects, bridging the funding gap across all technology readiness levels.
    - **Case Study:** BASF Horizon Europe projects
- **Advocate for transition tax credits:** To overcome the massive capital requirements of industrial transformation, businesses should advocate for targeted fiscal policies. Transition tax credits and government loan guarantees provide essential financial relief for companies investing in the research, development, and scaling of sustainable chemistry solutions.
- **Enable public procurement preferences:** Government purchasing commands massive market power that can instantly legitimize and scale new technologies. Advocating for public procurement policies that prioritize or mandate the use of sustainable and safe chemicals creates a guaranteed baseline market, helping innovators drive down costs for the broader economy.

Next Steps

Appendix

Lexicon

- **Hazard Classification:**
  - **Aquatic Toxicity**
  - **Bioaccumulative:** Substances that cannot be eliminated by living organisms and tend to bioaccumulate, which means they become more concentrated throughout the food chain. Concentrations of these substances can reach levels that are harmful to human health or the environment.[64] (AFIRM)
  - **Carcinogenic:** A substance where a relationship has been established between exposure to the substance and human cancer.[65] (AFIRM)
  - **CMR**
  - **Chemicals of High Concern (CoHCs)**: "A carcinogen, mutagen, or developmental/reproductive toxicant; persistent, bioaccumulative and toxic substance (PBT); or any other chemical for which there is scientific evidence of probable serious effects to human health or the environment that give rise to an equivalent level of concern - such as endocrine disruption - or a chemical whose breakdown products result in a CoHC that meets any of the above criteria."[66]
  - **Developmental Toxicant**
  - **EDC**
  - **Endocrine Disruptor:** A substance of very high concern that mimics or inhibits the effects of hormones. Many of these substances are also CMRs.[67] (Clean Production Action)
  - **Genotoxic**
  - **GRAS**
  - **Hazardous Chemicals:** the IIHC defines hazardous chemicals as "(A) substances meeting the Substances of Very High Concern (SVHCs) criteria as defined in Article 57 of the REACH regulation; (B) substances meeting the criteria as Substances of Concern (SoCs) as defined in Annex 2 of the Corporate Sustainability Reporting Directive (CSRD); and (C) persistent chemicals, i.e. organic substances meeting the persistence criteria in Article 57d of the REACH regulation."[68] (ChemSec)
  - **Hazardous Substances:** Substances that are primarily classified as carcinogenic, mutagenic, reprotoxic (CMR), persistent, bioaccumulative and toxic (PBT), very persistent and very bioaccumulative (vPvB), endocrine disruptors (ED), persistent, mobile and toxic (PMT & vPvM), respiratory sensitiser or raising an equivalent concern.[69] (ZDHC)
  - **Immunotoxicant**
  - **Neurotoxicant**
  - **Novel Entities: "**Novel entities are 'new substances, new forms of existing substances, and modified life forms that have the potential for unwanted geophysical and/or biological effects.' They include chemicals, plastics, other types of engineered materials or organisms not previously known to the Earth system, and naturally occurring elements (such as heavy metals) that are mobilized by human activities."[70]
  - **Persistent, Bioaccumulative and Toxic (PBT):** Chemical that is toxic, persists in the environment and bioaccumulates in food chains and, thus, poses risks to human health and ecosystems.[71] (Clean Production Action)

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[64] AFIRM (Apparel and Footwear International RSL Management Group). (2021). *AFIRM Chemistry Toolkit.*

[65] AFIRM (Apparel and Footwear International RSL Management Group). (2021). *AFIRM Chemistry Toolkit.*

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[67] Clean Production Action, Greenscreen. (2021, April). *The Retailer's Guide to Safer Chemicals and Materials*.

[68] ChemSec (The International Chemical Secretariat). (2024). *A Profitable Detox: Why safer chemistry makes financial sense*.

[69] ZDHC Foundation. (n.d.). ZDHC Knowledge Base - Glossary.

[70] Planet Tracker. (2024, September). *Novel Entities: A Financial Time Bomb - Why investors need to be aware of the risks and impacts of toxic artificial chemicals.*

[71] Clean Production Action, Greenscreen. (2021, April). *The Retailer's Guide to Safer Chemicals and Materials*.

- **Persistence:** An attribute of a substance that describes the length of time that the substance remains in a particular environment before it is physically removed or chemically or biologically transformed.[72] (Clean Production Action)
- **PMT**
- **Reproductive Toxicant**
- **Respiratory Sensitizer**
- **SIN List:** Substitute It Now (SIN) List, a list created by Chem-Sec of chemicals that meet the criteria for SVHCs under REACH and should be substituted with safer alternatives.[73] (ChemSec)
- **Skin Sensitizer**
- **SVHCs:** Substances of Very High Concern, chemicals that pose significant risks to human health or the environment, as defined by the EU REACH regulation.[74] (ChemSec)
- **Teratogen**
- **Toxic**
- **vPvB**

- **Material Types:**
  - **Adhesives**
  - **Colorants / Dyes / Pigments**
  - **Emollients**
  - **Microplastics**
  - **Nanomaterials**
  - **PFAS:** Per- and polyfluoroalkyl substances, a group of man-made chemicals that are resistant to water, oil, and heat.[75] (ChemSec)
  - **Phthalates**
  - **Plasticizers**
  - **Polymers**
  - **POP:** Persistent Organic Pollutant, a toxic chemical that adversely affects human health and the environment over a long period.[76] (ChemSec)
  - **Preservative:** A chemical substance used to preserve organic materials from decomposition or fermentation.[77] (AFIRM)
  - **Sealants**
  - **Solvent:** A substance that could dissolve other substances, such as oils, or in which another substance is dissolved, forming a solution.[78] (AFIRM)
  - **Stabilizers**
  - **Surfactants**
- **Assessment:**
  - **Alternatives Assessment:** A process for identifying, comparing and selecting safer alternatives to chemicals of concern (including those in materials, processes or technologies) based on their hazards, performance, and economic viability. A primary goal of alternatives assessment is to reduce risk to humans and the environment by identifying safer choices.[79] (Clean Production Action)
  - **Chemical Footprint:** "The total mass of chemicals of high concern (CoHCs) used by an event, organization, service, building, or product."[80] (Chemical Footprint Project)
  - **Comparative Chemical Hazard Assessment (CCHA)**
  - **Exposure Assessment**
  - **Functional Use Analysis**

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[72] Clean Production Action, Greenscreen. (2021, April). *The Retailer's Guide to Safer Chemicals and Materials*.
[73] ChemSec (The International Chemical Secretariat). (2024). *A Profitable Detox: Why safer chemistry makes financial sense*.
[74] ChemSec (The International Chemical Secretariat). (2024). *A Profitable Detox: Why safer chemistry makes financial sense*.
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[78] AFIRM (Apparel and Footwear International RSL Management Group). (2021). *AFIRM Chemistry Toolkit*.
[79] Clean Production Action, Greenscreen. (2021, April). *The Retailer's Guide to Safer Chemicals and Materials*.
[80] The Chemical Footprint Project. (n.d.). About the Project.

- **Hazard Assessment:** The process of determining under what exposure conditions (e.g., substance amount, frequency and route of exposure) a substance can cause adverse effects in a living system. Toxicology studies are used to identify the potential hazards of a substance by a specific exposure route (e.g., oral, dermal, inhalation) and the dose (amount) of substance.required to cause an adverse effect.[81] (Clean Production Action)
  - **Life Cycle Assessment**
  - **Multi-Criteria Decision Analysis (MCDA)**
  - **Quantitative Structure-Activity Relationship (QSAR)**
  - **Risk Assessment**
  - **Safety Assessment**
  - **Sustainable Assessment**
- **Substitution & Design:**
  - **Atom Economy**
  - **Benign By Design**
  - **Biomimetic Chemistry**
  - **Catalysis (As A Sustainability Lever)**
  - **Candidate List:** "A list of substances that are candidates for inclusion in the Authorisation List due to their hazardous properties. These substances are also known as Substances of Very High Concern (SVHCs)."[82] (ChemSec)
  - **Chemicals Policy**: A statement of how a company manages chemicals in its materials, supply chains, products, and operations beyond what is required by regulation.[83] (Clean Production Action)
  - **Chemical Substitution**
  - **Circular**
  - **Cradle To Cradle**
  - **Design For Degradation**
  - **Ecodesign:** the integration of environmental sustainability considerations into the characteristics of a product and the processes taking place throughout the product's value chain.[84] (European Parliament)
  - **Feedstock**
  - **Functional Substitution**
  - **Future Fit Materials**
  - **Green Chemistry**: "The design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances."[85] (Change Chemistry)
  - **Informed Substitution**
  - **Inherently Safer Design**
  - **Just Transition: "**A just transition ensures that environmentally sustainable economies are promoted in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind. It aims to ensure that the transition to net-zero emissions and climate resilience is orderly, inclusive and just."[86]
  - **Low Carbon**
  - **Net Zero**
  - **Planetary Boundaries:** "There are nine planetary boundaries which provide limits on humanity's production of certain types of pollution (such as carbon dioxide and chemical releases) and natural resource use (such as freshwater use). The boundaries are linked to global biophysical and biochemical

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[81] Clean Production Action, Greenscreen. (2021, April). *The Retailer's Guide to Safer Chemicals and Materials*.
[82] ChemSec (The International Chemical Secretariat). (2024). *A Profitable Detox: Why safer chemistry makes financial sense*.
[83] Clean Production Action, Greenscreen. (2021, April). *The Retailer's Guide to Safer Chemicals and Materials*.
[84] European Parliament and Council of the European Union. (2024, June 13). Regulation (EU) 2024/1781: Establishing a framework for the setting of ecodesign requirements for sustainable products. Official Journal of the European Union, L 2024/1781.
[85] Joint Statement on Using Green Chemistry and Safer Alternatives to Advance Sustainable Products. *Change Chemistry*, 2016.
[86] United Nations Global Compact. (n.d.). Accelerating action for a just transition.

processes that are known to regulate the state of the planet and maintain the stability that is conducive to human welfare and societal development. Novel Entities are one of the nine planetary boundaries."[87]
    - **Process Intensification**
    - **Regrettable Substitution**
    - **Renewable Feedstocks**
    - **RSL / MRSL:** A list of chemicals that are regulated via limiting or restricting chemicals in final products due to their potential harmful impact on human health and the environment. RSLs are typically developed by industry associations, governments, or individual companies to ensure that products and materials used in manufacturing processes meet specific safety and environmental standards.[88] (ZDHC)
    - **Safer Alternative:** A chemical, material, product, process or technology that is less hazardous for humans and the environment than the existing approach.[89] (Clean Production Action)
    - **Safer Solvents and Auxiliaries**
    - **SSbD**
    - **Sustainable Chemistry**: "The development and application of chemicals, chemical processes, and products that benefit current and future generations without harmful impacts to humans or ecosystems."[90] (Expert Committee on Sustainable Chemistry)
    - **Watch List:** A list of chemicals of concern that a company does not currently prohibit, but is considering prohibiting in the future due to scientific evidence that a chemical may cause harm to human health or the environment.[91] (Clean Production Action)
- **Equity & Justice:**
    - **Cumulative Burden**
    - **Environmental Justice**
    - **Externalities**
    - **Fenceline Communities**
    - **Free, Prior And Informed Consent (FPIC)**
    - **Toxic Hotspots**
    - **Triple Planetary Crisis:** "The triple planetary crisis refers to the three main interlinked issues that humanity currently faces: climate change, pollution and biodiversity loss. Each of these issues has its own causes and effects and each issue needs to be resolved if we are to have a viable future on this planet."[92]
- **Finance & Market Shaping:**
    - **Blended Finance**
    - **Business Value Creation**
    - **Data Trust**
    - **Impact-Weighted Accounting**
    - **Offtake Agreement**
    - **Pooled Demand / Demand Aggregation**
    - **Pre-Competitive Collaboration**
    - **True Cost Accounting**
- **Scaling:**
    - **Cost Parity**
    - **Drop-In Replacement**
    - **Economies of Scale**
    - **First-Of-A-Kind (FOAK) Plant**
    - **Incumbent Advantage**
    - **Infrastructure Compatibility**
    - **Lock-In Effect**
    - **Path Dependency**

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[87] Planet Tracker. (2024, September). *Novel Entities: A Financial Time Bomb - Why investors need to be aware of the risks and impacts of toxic artificial chemicals*.

[88] ZDHC Foundation. (n.d.). ZDHC Knowledge Base - Glossary.

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[91] Clean Production Action, Greenscreen. (2021, April). *The Retailer's Guide to Safer Chemicals and Materials*.

[92] United Nations Framework Convention on Climate Change (UNFCCC). 2022, April 13. *What is the Triple Planetary Crisis?*

    - **Performance Parity**
    - **Technology Readiness Level (TRL)**
    - **Valley Of Death (Innovation Finance Gap)**
- **Policy:**
    - **Direct Regulation**
    - **Extended Producer Responsibility (EPR)**
    - **Information Based Policy**
    - **Polluter Pays Principle**
    - **Price-Based Policy**
    - **REACH:** The European Union's regulation concerning the Registration, Evaluation, Authorization and Restriction of Chemicals aims to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances and 'articles'. REACH regulation must be met for all articles entering the EU.[93] (AFIRM)
    - **Rights-Based Policy**

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