DISKUSSIONSPAPIER

02/2026

A sustainable chemicals economy in Europe – vision, pathways to action and new approaches to cooperation for a competitive and sustainable business location

Discussion paper for the thematic conference ‘Spotlights 2026: Shaping the Chemical Transition Together’

by:

Nannett Aust-Watzlaw, Christopher Blum, Ute Dauert, Jeremias Herberg, Christian Kitazume, Janek Kubelt, Maximilian Pagel, Johannes Schwan, Volker Strauß, Lena Vierke, Klara Winkler

German Environment Agency, Dessau-Roßlau

Publisher:

German Environment Agency

German Environment Agency

Umwelt Bundesamt

DISKUSSIONSPAPIER 02/2026

A sustainable chemicals economy in Europe – vision, pathways to action and new approaches to cooperation for a competitive and sustainable business location

Discussion paper for the thematic conference ‘Spotlights 2026: Shaping the Chemical Transition Together’

by

Nannett Aust-Watzlaw, Christopher Blum, Ute Dauert, Jeremias Herberg, Christian Kitazume, Janek Kubelt, Maximilian Pagel, Johannes Schwan, Volker Strauß, Lena Vierke, Klara Winkler

German Environment Agency, Dessau-Roßlau

This paper summarises the current findings from the authors’ perspective.

Imprint

Publisher
German Environment Agency
Wörlitzer Platz 1
06844 Dessau-Roßlau
Tel: +49 340-2103-0
Fax: +49 340-2103-2285
buergerservice@uba.de
Website: www.umweltbundesamt.de

Completion date:
September 2026

Editorial team:
Chemical Transition Project Group of the German Environment Agency
Nannett Aust-Watzlaw

Authors:
Nannett Aust-Watzlaw
Scientific Officer in Division IV 1.1 'International Chemicals Management'.

Christopher Blum
Scientific Officer in Division IV 1.1 'International Chemicals Management'.

Ute Dauert
Head of Division II 4.2 'Air Quality Assessment'.

Jeremias Herberg
Head of the Executive Division.

Christian Kitazume
Scientific Officer in Division III 1.2 'Product Responsibility – Electrical Appliances, Vehicles and Batteries'.

Janek Kubelt
Scientific Officer at the German Environment Agency's Trace Substances Centre.

Maximilian Pagel
Scientific Officer in Division V 1.2 'Strategies and Scenarios for Climate Protection and Energy'.

Johannes Schwan
Scientific Officer in Division III 2.1 'Cross-cutting Issues, Chemical Industry, Combustion Plants'.

Volker Strauß
Head of Department IV 2 'Pharmaceuticals, Chemicals and Substance Testing'.

Lena Vierke
Scientific Officer in Division IV 2.3 'Chemicals' and in PB 3 "Presidents Office International Relations".

Klara Winkler
Scientific Officer in Division I 1.4 ‘Economic and Social Science Environmental Issues, Sustainable Consumption’.

DOI:
https://doi.org/10.60810/openumwelt-8841

Dessau-Roßlau, September 2026

Brief description: A sustainable chemicals economy in Europe – vision, pathways to action and new approaches to cooperation for a competitive and sustainable business location

The European chemicals economy is of central importance to the economy and society. Chemicals and derived materials are used in almost all economic sectors and areas of life. However, chemicals and derived materials can also have a negative impact on human health and the environment and, throughout their life cycle, contribute to the pollution and biodiversity crisis.

At present, the chemicals economy – and the chemical industry in particular – in Europe is facing one of the most challenging periods in its history. Maintaining Europe as a business location and further developing the chemicals economy into a sustainable, competitive and future-proof industry that operates within planetary boundaries is strategically and environmentally sound and requires a fundamental rethinking.

In view of the increasing pressure to act on both the economy and the environment, business, government and society can and must commit to an ambitious transformation.

The German Environment Agency (UBA) plays a constructive role in the discussion on a sustainable chemicals economy.

This discussion paper sets out a vision for a greenhouse gas-neutral, fossil-free and circular European chemicals economy that operates within planetary boundaries, avoids harmful impacts on people and the environment, drives innovation, and ensures competitiveness and social prosperity. The pathways outlined include defossilisation, resource and energy efficiency, circular economy approaches, safe and sustainable chemicals, a socially just transition, and international cooperation. The paper considers technological and economic innovations as well as sufficiency, new business models and a reliable policy framework.

The discussion paper aims to stimulate a constructive discussion on a vision for the transformation during the conference ‘Spotlights 2026: Shaping the Chemical Transition Together’.

Kurzbeschreibung: Eine nachhaltige Chemikalienwirtschaft in Europa – Vision, Handlungspfade und neue Kooperationsansätze für eine wettbewerbs- und zukunftsfähigen Wirtschaftsstandort

Die europäische Chemikalienwirtschaft ist für die Wirtschaft und Gesellschaft von zentraler Bedeutung. Chemikalien und daraus hergestellte Materialien werden in nahezu allen Wirtschaftssektoren und Lebensbereichen eingesetzt. Chemikalien und daraus hergestellte Materialien können jedoch auch negativ auf die menschliche Gesundheit und Umwelt wirken und im Laufe ihres Lebenszyklus zur Verschmutzungs- und Biodiversitätskrise beitragen.

Aktuell befindet sich die Chemikalienwirtschaft und speziell die Chemische Industrie in Europa in einer der herausforderndsten Phasen ihrer Geschichte. Europa als Wirtschaftsstandort zu erhalten und die Chemikalienwirtschaft zu einer nachhaltigen, wettbewerbs- und zukunftsfähigen Industrie weiterzuentwickeln, die sich in den planetaren Grenzen bewegt, ist aus strategischen und ökologischen Gründen sinnvoll und mit einem Neu-Denken verbunden.

Angesichts des steigenden Handlungsdrucks für Wirtschaft und Umwelt können und müssen sich Wirtschaft, Staat und Gesellschaft auf eine ambitionierte Transformation einlassen.

Das Umweltbundesamt (UBA) nimmt eine konstruktive Rolle in der Diskussion um eine nachhaltige Chemikalienwirtschaft ein.

Das Diskussionspapier formuliert eine Vision für eine treibhausgasneutrale, fossilfreie und zirkuläre europäische Chemikalienwirtschaft, die innerhalb der planetaren Grenzen wirtschaftet

und schädliche Auswirkungen auf Mensch und Umwelt vermeidet, Innovation voranbringt sowie Wettbewerbsfähigkeit und gesellschaftlichen Wohlstand sichert. Die aufgezeigten Handlungspfade umfassen Defossilisierung, Ressourcen- und Energieeffizienz, Kreislaufwirtschaft, sichere und nachhaltige Chemikalien, einen sozial gerechten Umbau sowie internationale Zusammenarbeit. Betrachtet werden dabei technologische und wirtschaftliche Innovationen ebenso wie Suffizienz, neue Geschäftsmodelle und verlässliche politische Rahmenbedingungen.

Das Diskussionspapier soll eine konstruktive Diskussion über ein Zielbild der Transformation während der Thementagung „Spotlights 2026: Shaping the Chemical Transition Together“ anregen.

Table of Contents

List of Figures

List of abbreviations

Abbreviations	Full form
BMUKN	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety
CAPCI	Climate Action Programme for the Chemical Industry
CEAP	Circular Economy Action Plan
CCU	Carbon Capture and Use
CO2	Carbon Dioxide
CSS	Chemicals Strategy for Sustainability
EU	European Union
GFC	Global Framework on Chemicals
GHS	Globally Harmonized System for Classification and Labelling
ISC3	International Sustainable Chemicals Collaborative Centre
PRTR	Pollutant Release and Transfer Register
PtH	Power-to-heat
SDG	Sustainable Development Goals
THG	Greenhouse gas
TPCI	Transition Pathway for the Chemical Industry
UBA	Umweltbundesamt, German Environment Agency
UNEP	United Nations Environment Programme
ZDHC	Zero Discharge of Hazardous Chemicals
ZPA	Zero Pollution Ambition

1 Introduction

Chemicals are an essential foundation of human life and the basis of many economic processes and products. Throughout their life cycle, chemicals are part of goods and services used to meet everyday needs such as housing, food, mobility, and the construction and operation of supply infrastructure (e.g. water or energy). They are therefore a cornerstone of our current standard of living.

Chemicals are used in many economic sectors and consumer areas – strategies and concepts for transforming towards sustainability that focus exclusively on the chemical industry are therefore too narrow. This paper therefore considers, where appropriate, the chemicals economy as a whole – i.e. the production of chemicals as well as their use in all economic sectors and consumer areas.

The chemicals economy is a key pillar of the economy and society in Europe. As an employer, it bears social responsibility for its employees. It is of strategic importance and a central lever for the transformation towards a sustainable economy and society as a whole.

Chemicals and derived materials are, and will remain, indispensable to sustainable and innovative application. At the same time, however, they can have adverse effects on human health and the environment and, over their life cycle, contribute to the pollution and biodiversity crisis. Problems such as global plastic pollution underline the need for a circular economy, to which the chemicals economy can make a significant contribution.

The production and further processing of chemicals requires a high level of energy input, which is associated with significant greenhouse gas emissions. In addition, most basic chemical feedstocks are derived from fossil and mineral resources, the extraction of which is often associated with considerable environmental impacts.

This results in an ambivalent public perception of the chemical industry in the narrower sense and of the chemicals economy in the broader sense, as both problem-solver and problem-causer.

Currently, the chemicals economy and in particular the chemical industry in Europe are in one of the most challenging phases of their history. An imbalance in global markets, demographic change, technological leaps, political tensions and wars, and not least the environmental crises (climate change, biodiversity loss and pollution) are weakening competitiveness and threatening Europe's chemical business location.

Maintaining and further developing Europe as a business location is sensible for strategic and environmental reasons and requires a new way of thinking. Innovative companies and research institutions are already increasingly committed to this. If this new way of thinking is translated into a wisely designed environmental and economic transformation, the current situation can become an opportunity for innovative business models and technologies. Competitiveness can be strengthened, prosperity preserved, and the foundations of life in terms of health, the economy, society and the environment can be protected. A transition towards a sustainable chemicals economy concerns us all – as consumers, employees, employers, researchers, representatives of public authorities and as responsible political actors.

The German Environment Agency (UBA), as a central institution for scientific environmental policy advice to the German Federal Government and as the enforcement authority for national and European environmental and climate legislation, plays a constructive role in the debate on a sustainable chemicals economy.

The UBA advocates a transformation of the economy and society towards a sustainable and future-proof way of doing business. It aims to achieve a pollution-free environment, healthy

ecosystems, climate protection and climate adaptation, as well as a circular economy. The UBA works to ensure that all stakeholders are aware of the planetary boundaries as a framework for action. The UBA seeks to make a significant contribution to enabling sustainable innovation and securing Europe's position as a business hub.

At the UBA-ISC3 thematic conference 'Spotlights 2026: Shaping the Chemical Transition Together' in October 2026, the UBA intends to analyse the situation together with representatives of all relevant stakeholder groups and identify possible courses of action. It is important to the UBA to jointly develop long-term viable solutions for an economically, ecologically and socially just business location.

The discussion paper, including the UBA's vision for a sustainable European chemicals economy in 2050 as presented therein, outlines—based on the challenging starting situation of the chemical industry—the key axes for a forward-looking and competitive development of the chemicals economy as a whole, taking into account environmental and climate protection. It thus serves as a substantive basis for the UBA-ISC3 thematic conference.

The discussion paper is intended to stimulate a constructive discussion on a vision for the transformation during the conference. It aims to invite key stakeholders to engage in a strategic dialogue on the long-term future of the chemicals economy in Europe and to identify challenges, potential conflicts of interest, areas of overlap and priority areas for action, as well as stakeholder-specific approaches.

2 The chemicals economy in Europe – strengths and challenges for sustainable development

Motivation for sustainable development in the chemicals economy

The prosperity of society and the economy depends directly and indirectly on intact ecosystems and on a sustainable (chemicals-)economy. On the one hand, this means that an unsustainable economy or an economy in crisis poses challenges for employers and employees. On the other hand, it means that economic and environmental crises pose a threat to the sustainable development of the (chemicals) industry. In other words: if companies in Europe and government institutions lose their capacity to act, the resulting social disruptions can further restrict planning certainty and, consequently, investment and innovation. Environmentally responsible business practices and coherent legislation by the state become more difficult in times of crisis – but at the same time more important.

It is therefore pivotal not to view the current difficult economic situation merely as an economic problem, but also as an opportunity for new alliances and courses of action. Climate protection and adaptation, healthy ecosystems, a pollution-free environment, circular business models, and coherent legislation can provide long-term stability for Europe as a business location and, in the short term, an incentive for innovation and investment. A sustainable chemicals economy can therefore act as an engine for growth and a driver of innovation.

Europe as a chemical industry hub

Manufacturers of chemicals – in other words, the chemical industry in the narrower sense – are a central pillar of the European economy. Chemical products are usually at the starting point of the value chain and are essential for the downstream industry as well as for manufacturers of consumer and capital goods.

In 2024, the sector in Europe generated a turnover of around 635 billion euro (Germany: 32 %)[1] , of which around 60 % was attributable to basic chemicals and intermediates. With around 1.2 million employees in 2024, the European chemical industry accounted for only a small proportion of jobs in the manufacturing sector[2]. However, wages in the sector were more than 40 % above the European manufacturing average, positioning the chemical industry not only as an important employer but also as a guarantor of tax revenue and prosperity. The sector is characterised by a heterogeneous business landscape: almost 90 % of companies in the chemical industry have fewer than 50 employees, yet they account for only 14 % of all jobs in the sector. By contrast, 3 % of companies (with more than 250 employees) account for 64 % of jobs and generate as much as 72 % of turnover. Furthermore, with a share of around 21 % in 2024, the chemical industry in Europe was the largest energy consumer of all European industrial sectors[3]. The chemical industry's energy supply relied to a large extent on fossil fuels, in particular natural gas (38 %) and petroleum products (15 %).

A distinctive feature of the sector is its strong economic networks and integrated material flows: for example, 83 % of chemical production in Germany is further processed within the sector itself[4] . This high degree of interconnection is particularly evident in chemical parks, where

[1] European Chemical Industry Council (Cefic). (2025). Industry data. facts & figures of the European Chemical Industry: 2025 Facts and Figures.

[2] Eurostat. (2026). Enterprise statistics by size class and NACE Rev. 2 activity (from 2021 onwards).

[3] Eurostat (2026) - Final energy consumption in industry – detailed statistics: The highest industrial energy consumers in the EU.

[4] Verband der Chemischen Industrie e.V. (2026). Chemie & Pharma - Schlüsselbranche für Industrie, Innovation und Transformation: Branchenporträt Juli 2026.

companies share infrastructure, create synergies and can thus benefit from efficiency gains. With regard to the chemical sector as a whole – including downstream industries, it becomes clear that the chemical industry is a key factor in stabilising the overall economic base[5] .

Economic challenges

Whilst production volumes in the chemical industry in Europe grew by around 20 % between 2000 and 2021, they fell by more than 10 % between 2021 and 2024. Since 2022, average capacity utilisation in Europe has stood at approximately 74 %. For companies, this represents a challenging business situation with potential consequences for the economy as a whole, as the European Commission also notes in its 'Chemicals Industry Action Plan'[6] .

There are many reasons for this:

- Impact of COVID: COVID-19 has caused a decline in industrial demand due to disrupted supply chains, whilst delays in research, production and regulatory processes have placed a significant short-term strain on the chemical industry.
- Dependencies: Energy- and raw material-intensive sectors of the chemical industry in particular, such as basic chemicals, are largely dependent on fossil fuel and raw material sources, which are often located outside Europe. Prices for these raw materials have risen in recent years, driven, amongst other things, by wars, international trade barriers and growing international demand.
- Skills shortage: Demographic change and market dynamics are driving the shortage of skilled labour.
- International competition: Growing competition from countries with lower production costs, as well as deliberately created overcapacity, is increasing the pressure on European production.
- Lack of investment: Necessary investment in industrial facilities to ensure a sustainable chemical industry is often lacking in Europe. Companies frequently invest closer to raw material sources or growing markets with lower production costs, thereby increasingly building up capacity in regions outside Europe.
- Regulatory environment: Uncertain political conditions holding back investment and innovation.

The consequences of these dynamics are severe for the chemical industy and have an impact on the entire downstream value chain – in other words, the chemical sector as a whole. A shift in thinking towards future viability, sustainability and competitiveness means changes for the entire value chain.

Environmental challenges

Changes to the environment (e.g. climate change or water availability) are affecting the economy, and this trend is set to intensify: the availability of resources previously taken for granted is no longer guaranteed, and human impact on ecosystems has reached alarming proportions globally. These factors are playing an increasingly significant role in the choice of

[5] Stolzenberg, H. C. et al. (2021). UBA fact sheet thought starter towards chemical intensity: A global, inclusive goal for the sustainable use of chemicals is needed to safeguard both societal wellbeing and earth's life-sustaining capacity.

[6] The Directorate General for Internal Market, Industry, Entrepreneurship and SMEs. (2025). Communication from the Commission to the institutions - European Chemicals Industry Action Plan.

production sites. More frequent extreme weather events, or conditions caused by such events (e.g. low water levels in rivers), can also lead to disruptions in supply chains, which further underlines the dependence on stable environmental conditions.

The growing global demand for and supply of chemical products is a major contributor to the exceeding of planetary boundaries[7]. Whilst environmental and industrial policy legislation in the EU has led to a significant reduction in the impact on people and the environment[8]. Nevertheless, recent measurements continue to indicate – or once again highlight – problems for the environment and human health caused by released chemicals[9]. Among other things, the production and release of pollutants such as plastics or persistent chemicals are a cause for concern[10] . The release of these substances into the environment threatens not only the foundations of life, but also the very foundations of the economy itself. This is because the economy is inextricably embedded in nature and cannot exist independently of it[11,12].

Transformation and future prospects

Due to the chemicals sector extensive interconnection with other industrial sectors, there is a risk of domino effects that could undermine Europe's position as a business location and its capacity for environmental action, thereby weakening both the maintenance of prosperity and the success of the transformation in Europe.

The chemicals economy, and the chemical industry in particular, faces a dual challenge: it must navigate a far-reaching environmental and economic transformation whilst remaining economically stable[13]. From this integrated perspective, many questions arise that must be discussed and answered jointly by stakeholders from business, government and society:

- How can chemicals and products be manufactured in a greenhouse gas-neutral manner using the raw materials and energy sources that will be available in the future, whilst also meeting the requirements of a circular economy and guaranteeing that they are free from harmful substances?
- How should political and regulatory frameworks be designed to support the transition towards a sustainable chemicals economy against the backdrop of the economic and environmental challenges described above in Europe? What requirements are appropriate in terms of the industry's willingness to change and its readiness to abandon established processes and business models?
- How can the indispensable capacity of the chemicals economy for innovation be harnessed to meet future challenges, and how can the framework conditions be established to enable the European chemical industry to thrive?
- How can Europe remain an attractive hub for science? How can the innovation environment be shaped to be dynamic, flexible, sustainable and forward-looking, so as to translate developments into practice? What role do spin-offs and start-ups play in the innovation

[7] Richardson, K., et al. (2023). Earth beyond six of nine planetary boundaries.

[8] Harremoës, P. & Gee, D. (2001). Environmental Issues Series: Bd. 22. Late lessons from early warnings: the precautionary principle 1896 - 2000.

[9] European Environment Agency; European Commission. (2025). Zero pollution monitoring and outlook 2025.

[10] Persson, L. et al. (2022). Outside the safe operating space of the planetary boundary for novel entities.

[11] Dasgupta, P. (2021). The economics of biodiversity: the Dasgupta review.

[12] Damania, R. et al. (2025). Reboot development: The economics of a livable planet.

[13] Mergner, L. et al. (2026). Lage und Risiken der chemischen Industrie: GWS Discussion Paper 2026/1.

ecosystem and in putting research findings into practice, and what support do they require? How can needs-based funding be ensured?

Both innovation and the right policy framework are needed in the chemicals economy as the key to securing competitiveness, employment and sustainability. Research and development organisations, employer and employee organisations, as well as investors and government bodies, can only successfully shape the transformation of the chemicals industry by working together.

3 A vision for a sustainable European chemicals economy as a basis for discussion

The following section presents the vision for a sustainable European chemicals economy from the perspective of the German Environment Agency (UBA), which serves as the starting point and basis for discussion for the thematic conference 'Spotlights 2026: Shaping the Chemical Transition Together' in October 2026.

The vision is guided by the European Commission's key strategies relating to the transformation of the chemicals economy, such as the Chemicals Strategy for Sustainability (CSS)[14], the Transition Pathway for the Chemical Industry (TPCI)[15], the European Chemicals Industry Action Plan[16], the EU Action Plan 'Towards Zero Pollution for Air, Water and Soil' (ZPA)[17] and the European Circular Economy Action Plan (CEAP)[18]. The vision is in line with the global objectives of the 2030 Agenda and its Sustainable Development Goals (SDGs)[19].

The UBA's vision is a commitment to environmental protection and sustainability; it recognises the central role of the European chemicals economy as a catalyst for the transformation of the economy as a whole, and outlines a forward-looking and competitive chemicals economy that leads the way in implementing this transformation and sets standards for a sustainable, resilient and regenerative future.

Vision for a sustainable European chemicals economy

In future, the European chemicals economy will comprise world-leading suppliers and users of innovative, sustainable solutions, as well as regenerative and net-zero practices across the entire life cycle of chemicals. These chemicals will cause no harmful effects to people or the environment. On this basis, the chemicals economy has transitioned to circular and greenhouse gas (GHG)-neutral products, production methods and business models, thereby operating within planetary boundaries.

People perceive the chemicals economy as a responsible social actor that has contributed to solving the climate, biodiversity and pollution crises, and whose products they can use in their everyday lives without hesitation.

Sufficiency is a guiding principle in business models within the chemical sector and the sectors that apply, process and utilise chemicals; it assesses the necessity of producing and using chemicals, whilst also considering non-chemical alternatives that fulfil the same functions and the option of abandonment.

The use of fossil raw materials is avoided. The raw materials used come from renewable or secondary sources. Raw material efficiency is maximised whilst minimising environmental impact.

[14] European Commission. Chemicals strategy: The EU's plan for a toxic-free environment.

[15] European Commission. (2023). Transition pathway for the chemical industry (First edition).

[16] The Directorate General for Internal Market, Industry, Entrepreneurship and SMEs. (2025). Communication from the Commission to the institutions - European Chemicals Industry Action Plan.

[17] European Commission. (2021). Comission Staff Working Document: Digital solutions for zero pollution.

[18] European Commission. Circular Economy: The EU aims to transition to a circular economy for a cleaner and more competitive Europe.

[19] United Nations. (2015). Transforming our world: The 2030 agenda for Sustainable Development.

Process-related GHG emissions from production and those arising during the life cycle are reduced to the technically feasible minimum, whilst energy efficiency is maximised. Unavoidable GHG emissions are offset or recycled through natural sinks, innovative technologies, and alternative feedstocks and processes.

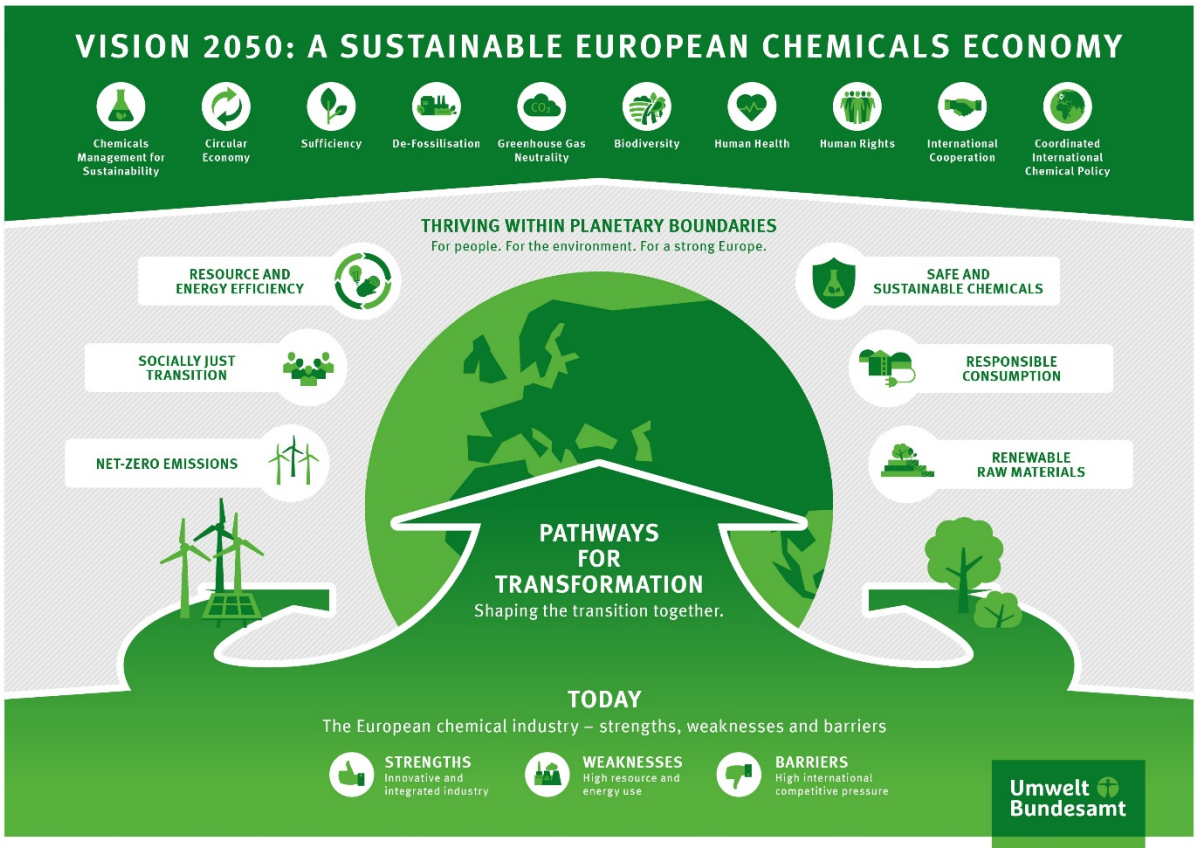
The principles of the circular economy are implemented across all areas of the chemicals economy to reduce raw material use, waste generation and the associated environmental impacts.

The management of chemicals throughout their life cycle is safe and sustainable, ensuring that there are no adverse effects on human health or ecosystems and that the EU's 'Zero Pollution Ambition' is met. Furthermore, the chemicals eonomy does not adversely affect biodiversity. Substances and products that enter the natural environment can be utilised there. The functionality of ecosystems is preserved.

The sustainable chemicals economy safeguards human rights and the health and well-being of all stakeholders and those working within the supply chains. It recognises its importance to workers and regions and drives the transformation in collaboration with them.

Cooperation with global partners on an equal footing ensures a fair exchange of proven sustainable practices and the establishment of and compliance with international standards for the sustainable management of chemicals throughout their entire life cycle. Political frameworks and a coordinated international chemicals policy promote the industry's forward-looking approach and prevent displacement effects (so-called 'leakage' effects). Existing conflicts of interest have been resolved through social dialogue.

Figure 1 : Vision for a sustainable European chemicals economy



Source: own illustration, UBA

4 Approaches and courses of action

Policies for transforming the chemicals economy can be categorised under the following themes: the energy transition, the raw materials transition, the circular economy, pollution and social sustainability. Specific levers can be identified for each policy area; however, these often do not operate in isolation but address several policy areas simultaneously.

4.1 Defossilisation and greenhouse gas neutrality

With regard to defossilisation and greenhouse gas neutrality (GHG neutrality) of the energy requirements and hydrocarbon raw materials of the chemicals economy, four levers can be identified:

- Energy transition in upstream sectors: An efficient transition to renewable energy reduces the demand for hydrocarbons as energy sources. Electricity-based hydrogen and its derivatives are used where electrification is not possible. The shift to renewables leads to a decline in demand for fossil fuels and power sources.
- Energy transition in the chemical industry: The chemical industry, as part of the industrial sector, must also electrify its energy requirements for processes and process heat. As part of this electrification, electricity demand must be made more flexible – that is, electricity consumption must be adapted to the available electricity supply in terms of both timing and volume wherever possible – as this makes a systemic contribution to the energy system.
- Raw materials transition and a closed-loop carbon economy: Fossil raw materials must be replaced by sustainable alternatives such as green hydrogen and its derivatives, as well as by circular carbon (recycled materials, CO_2 from capture or the atmosphere, biogenic residues). A closed-loop carbon economy is crucial to achieving GHG neutrality. The utilisation of atmospheric carbon and its incorporation into durable products can enable negative emissions.
- Durability and circularity in downstream products: Products must be more durable and form part of a circular economy.

GHG neutrality and the replacement of fossil raw materials with recycled materials offer the opportunity to establish Europe as a key player in the global transition and to strengthen its economy in a lasting and sustainable manner. Europe can draw on its technical expertise and its position as an attractive hub for science. Furthermore, Europe has access to secondary raw materials to build a competitive circular economy.

However, the limited availability of renewable energy is a disadvantage for the region. A key approach to addressing this is to develop a **prioritisation strategy**. In view of scarce and expensive resources, policymakers, industry and society must jointly define which chemical value chains are indispensable for **European sovereignty** and the transition.

The focus should be on innovation, process engineering and applications that remain competitive in the long term, so that, together with the mechanical and plant engineering sector, solutions can be offered to close technical carbon cycles and tap into new markets.

4.2 Resource and energy efficiency

The chemical industry has continuously improved its processes in terms of resource and energy efficiency – not least to save costs. Value chains have become increasingly efficient over the

decades, leaving only limited scope for incremental improvements in established industrial processes – particularly in the case of basic chemicals, where by-products often open up new value chains[20].

This linear, highly interconnected production model is characterised by significant inertia. As a result, new, more sustainable processes cannot always be readily integrated into existing value chains at chemical sites, for example, if doing so would make existing plants less economically viable.

Furthermore, it is becoming apparent that what appears resource-efficient within the industry or a value chain may present a different picture from a life-cycle perspective. A significant proportion of the chemical industry's products cannot be reintroduced into the material cycle at the end of their life cycle, but are instead treated solely as waste for energy recovery.

This presents an opportunity to tap into previously untapped potential for efficiency in resource use, whilst at the same time reducing the European chemical industry's strategic dependence on (fossil) raw material imports.

Four key levers can be identified for increasing resource and energy efficiency in the chemical industry:

- Power-to-Heat (PtH), i.e. the generation of heat from electrical energy, can – depending on the application – significantly improve the energy efficiency of processes by utilising ambient heat. Ideally, electrification also goes hand in hand with greater flexibility in plant operations[21].
- Waste heat recovery: Improved utilisation of waste heat from chemical processes increases their energy efficiency, with the potential being particularly high in medium-sized and smaller plants[22]. Techniques such as steam compression can recover waste heat and enable the energy-efficient provision of heat at temperatures of up to 150 °C[23].
- Sufficiency: The chemicals economy will (due to its high energy, raw material and land intensity) continue to pose risks to people and the environment. A consistent sufficiency strategy helps to avoid unnecessary demand for chemical products. By targeting changes in production and consumption patterns, it aims to reduce environmental impacts, health risks and resource consumption throughout the entire value chain.
- Circular economy: Closed material cycles offer the potential to improve the energy balance of material flows in the chemical industry. It must be noted, however, that recycling potential within the chemical industry is limited insofar as basic chemicals, in particular, are converted into other substances and products and can therefore – if at all – only be kept in the cycle through chemical recycling and carbon capture and utilisation (CCU) following incineration or pyrolysis. Innovations are needed to bring about improvements in this area.

[20] Sheldon, R. A. (2023). The E factor at 30: a passion for pollution prevention.

[21] Rosental, M. et al. (2024). Prozessintegrierte Maßnahmen und alternative Produktionsverfahren für eine umweltschonendere Herstellung von Chemikalien.

[22] Bazzanella, A. & Ausfelder, F. (2017). Low carbon energy and feedstock for the European chemical industry.

[23] A.SPIRE. (2021). Strategic research and innovation agenda.

4.3 Circular economy

The material use of raw materials remains largely linear in nature: raw materials are extracted, processed into products and, at the end of their life, are often disposed of separately – that is, without being returned to the cycle. The following eight levers of the circular economy are key[24].

- Leaving fossil raw materials in the ground: Fossil raw materials cause greenhouse gas emissions, even when they are incorporated into long-lasting products. Alternatives, such as recycled carbon or sustainable biomass, are crucial for preserving natural carbon sinks.
- Shaping the bioeconomy to be circular: The bioeconomy offers potential for the use of alternative raw materials, but also causes significant environmental impacts (water use, land use, eutrophication). Efficiency gains are achieved through the cascading use of biomass and the protection of intact ecosystems.
- Avoiding pollutants: Many chemicals, such as plasticisers or microplastics, harm people and the environment and hinder material cycles. Replacing them with alternative materials or through systemic solutions reduces the effort required for recycling and waste disposal.
- High-quality, single-material recycling: Single-material recycling minimises downcycling and secures raw materials. This requires clean waste separation and materials free from pollutants.
- Closing carbon and nutrient cycles: Closed cycles for carbon, nitrogen and phosphorus reduce the ecological footprint. These include chemical recycling, CO_2 utilisation (CCU) and material cycles that preserve functionality.
- Making better use of waste heat: Waste heat should be utilised within the technosphere for as long as possible – for example, through heat pumps for process heat or building heating – to minimise energy losses.
- Designing products for circularity: Durable, repairable and non-toxic products with clear material declarations facilitate recycling and extend the service life.
- Sufficiency in product use: A longer service life for products, such as textiles, reduces the release of chemicals and GHGs into ecosystems and the atmosphere.

The challenge for the circular economy is that internal company-wide cycles often already exist, but they need to be expanded across sites, product life cycles and national borders. Tailor-made solutions and careful consideration are needed to transform the chemicals economy within planetary boundaries.

4.4 Safe and sustainable chemicals

Through sustainable innovation, the creation of new value and global market leadership in safe products, environmental impacts (e.g. on air, water and soil) can be minimised, supply chain security strengthened and public health promoted. The following four levers are key in this regard:

- Sufficiency: Necessity before growth – avoiding harmful or superfluous chemicals (e.g. substances with properties of concern, single-use products) in favour of non-harmful alternatives. Industrial sufficiency means shifting the economic focus from the volume sold

[24] Kosmol, J. et al. (2025). Zirkuläres Wirtschaften als Beitrag zur nachhaltigen Entwicklung in unsicheren Zeiten.

to the benefit delivered ('Value over Volume'). Through intelligent process design and business models such as chemical leasing, the elimination of unnecessary substances becomes a driver for cost reduction, risk minimisation and technological market leadership[25,26] . The transformation thus presents an opportunity for strategic streamlining, creating an agile and future-proof business location. Lock-in effects caused by chemical-based products should be avoided.

- Circular economy: Products must be designed to be durable, reusable, repairable and recyclable. Substances that are harmful or interfere with recycling must be phased out, and transparent information sharing must be established along supply chains across entire life cycles (e.g. via digital product passports).
- Integrated chemicals management: A 'zero pollution ambition' requires the prevention of harmful emissions at all stages of the life cycle. Sustainable product design (e.g. in accordance with the guidelines of the 'Safe and Sustainable by Design' framework) should therefore become standard practice, ensuring that chemicals with properties of concern are avoided or, where subtituion is not possible, their release into the environment is prevented. In doing so, it is important also to take also sustainability criteria for chemicals into account (e.g. regarding ecosystems and biodiversity, exposure risks) through life-cycle assessment methods and to make this information transparent via centralised databases. Public administration must be further developed to ensure that legislation is implemented and optimised in an efficient, coherent and transparent manner.

These levers require new forms of collaboration, not least to create dynamic, sustainability-oriented innovation ecosystems: academia, industry, politics and NGOs must work together to create the conditions for driving forward innovation, research, smart regulation and the exchange of knowledge. Stakeholders from universities and businesses must step up their efforts to jointly develop environmentally and climate-friendly substances, processes and products, as well as standards and certification tools. Publicly accessible tools such as the UBA ChemSelect[27] and EU guidelines on 'Safe and Sustainable by Design'[28] and the 'Key Characteristics of Sustainable Chemistry'[29] can support companies in selecting more sustainable chemicals. Stakeholder dialogues can promote the continuous development of standards, indicators and decision-making tools.

The development of strategic approaches to establishing integrated and automated regulatory cycles (production – life cycle – ecosystems) can ensure comprehensive due diligence checks throughout the supply chain and enable digital traceability.

4.5 Socially just transition

The transformation of the chemicals economy brings with it far-reaching changes: new, sustainable production processes will replace existing ones, leading to different products and a changed range of goods on offer, and causing shifts in the market. Strategic decisions must be made as to which sectors of the industry are to be preserved, where necessary through state

[25] United Nations Industrial Development Organization. The performance based business modell for sustainable chemicals management.

[26] German Environment Agency (UBA). Chemikalienleasing.

[27] German Environment Agency (UBA). ChemSelect – assessing the sustainability of chemicals.

[28] Garmendia Aguirre, I. et al. (2025). Safe and sustainable by design chemicals and materials: Revised framework (2025).

[29] International Sustainable Chemistry Collaborative Centre (ISC3). Key characteristics of sustainable chemistry.

funding – particularly in view of limited financial resources. The aim is a socially responsible and socially acceptable transformation.

To achieve this, clear, long-term and reliable targets and instruments – such as taxes, subsidies and market-based instruments like climate protection agreements – are crucial. These provide predictability for businesses and promote innovation, which, due to long investment cycles (20–30 years), must be planned today with a view to 2045. Within the EU, a wide range of instruments are currently being created and reoriented in terms of their focus, such as the EU Structural Funds, the Competitiveness Fund and green lead markets, which are intended to drive the achievement of policy targets.

As a key sector, the chemical industry has an important role to play as a responsible stakeholder: it can invest in innovation, develop transition plans and create future prospects for its employees. At the same time, society is called upon to accept and help shape change – for example, through conscious consumption or participation in regional transformation processes. Politicians and public authorities must establish a meaningful framework for this.

Regions with intensive production in the chemical industry in the narrower sense and the chemicals economy in the broader sense – for example, in chemical parks and clusters – are particularly affected. Here, suitable development prospects and participatory formats are needed to engage employees and local residents and to make the region fit for the future. For employees, further training and socio-cultural support are crucial, as job profiles and life paths may change significantly. Acceptance is fostered through transparency, communication and the opportunity to take effective action themselves.

4.6 International cooperation

Global chemical production is based on international cooperation. The exchange of resources, knowledge, capital, imports and exports, as well as environmental and social standards, is interconnected across many countries, and supply chains are structured on a global scale. From a global perspective, locations differ in terms of energy prices, labour, infrastructure and environmental regulations. All the courses of action described so far have an international dimension that extends well beyond European cooperation.

Global partnerships between the public sector, industry and academia enable dynamic innovation ecosystems in Europe. These include flagship markets geared towards sustainable innovation and market leadership in areas where Europe has unique selling points[30]. A long-term focus creates planning certainty and, consequently, resilience within the sector.

The Global Framework on Chemicals (GFC) provides a basis for translating shared commitment to collective responsibility into mutually beneficial international cooperation. Collaboration is particularly promising when all stakeholders exchange knowledge and technologies within international networks, consortia and start-up ecosystems, and achieve greater effectiveness through international agreements, standards and cooperation.

As a global, voluntary framework, the GFC – through a multi-sectoral and multi-stakeholder approach – encourages stakeholders from governments and public authorities, industry, academia and civil society to manage chemicals and waste safely and sustainably throughout their entire life cycle. It complements regulatory instruments, such as the internationally binding conventions on substances (the Basel, Rotterdam, Stockholm, Minamata and Montreal Conventions), in which problematic substances are identified, prioritised and addressed. The

[30] Pagel, M. et al. (2026). Bis 2040 Treibhausgase um mindestens 90 Prozent mindern So kann es gehen!

GFC thus provides a forum for regulatory synergies and is, furthermore, an essential platform for joint policy-making, capacity-building and data exchange.

Within global value and supply chains, it is not only the GFC that aims to ensure that stakeholders in the chemicals economy enhance their social and environmental responsibility. Tools for achieving this include harmonised standards or instruments such as the Globally Harmonised System (GHS) or the Pollutant Release and Transfer Registers (PRTRs). The exchange of information on chemicals in materials and products throughout their entire life cycle (e.g. via the Digital Product Information System) and sustainable strategies in chemicals and waste management (e.g. through chemical footprint approaches) are also necessary. With a focus on equitable technology and knowledge transfer between developing and industrialised countries, the aim is to bring innovative and sustainable solutions to market there through sustainable business models.

To translate these global ambitions into operational practice, targeted international capacity-building is essential. The transition to a sustainable chemicals economy can only succeed if partner countries are empowered not only to adopt modern environmental and safety standards, but also to manage them independently, embed them institutionally and continuously adapt them to local requirements. This requires a systematic transfer of knowledge in the fields of regulation, science and industry. This includes, amongst other things, joint R&D programmes on climate protection (e.g. to reduce GHG emissions), investment in renewable energy and its infrastructure, safe and sustainable chemicals management (e.g. in the Climate Action Programm for the Chemical Industry (CAPCI)[31]) and the promotion of circularity across national borders (e.g. chemical leasing or the Zero Discharge of Hazardous Chemicals Programme (ZDHC)[32]).

The transition to a safe, GHG-neutral, circular and equitable chemicals economy can only be achieved at a global level through collective action. To this end, governments, companies and research institutions must disseminate appropriate approaches and technologies worldwide, including through coordinated frameworks (e.g. the Global Framework on Chemicals), technology and knowledge transfer (e.g. UNEP Global Environmental Facility Projects) and multilateral forums (e.g. the Berlin Forum on Chemicals).

[31] International Sustainable Chemistry Collaborative Centre (ISC3). Climate Action Programme for the Chemical Industry – CAPCI: Strengthening the contribution of the chemical industry to climate protection.

[32] ZDHC Foundation. (2026). Better chemistry for a healthier planet.

5 The way forward

The European chemicals economy faces major economic and environmental challenges. At the same time, thanks to the strength of the European market, the chemicals economy has the potential to become a pioneer in economic, environmental and social sustainability.

In view of the mounting pressure to act on economic and environmental fronts, business, government and society can and must commit to an ambitious transformation, shaped by public discourse. Agreement on a vision for a sustainable chemicals economy can form the basis for this transformation.

In order to realise the vision outlined in this discussion paper, the key stakeholders in business, science, politics, public administration and civil society must consistently promote a cooperative dialogue. Only then can Europe develop into a stable, innovative and environmentally and socially sustainable location for the chemicals economy. To guarantee the achievement of climate and environmental targets and thereby create planning certainty, it is important to have cross-party and cross-legislative commitments to ambitious climate and environmental targets, as well as legal requirements.

The UBA's vision presents a future scenario for discussion. In this way, the UBA, as Germany's central environmental authority, offers itself as a partner in the discussion on the future of the chemicals economy.

Bibliography

A.SPIRE. (2021). *Strategic research and innovation agenda*. https://www.aspire2050.eu/sites/default/files/users/user85/p4planet_07.06.2022._final.pdf [last accessed on 9 September 2026]

Bazzanella, A. & Ausfelder, F. (2017). *Low carbon energy and feedstock for the European chemical industry*. https://dechema.de/dechema_media/Downloads/Positionspapiere/Technology_study_Low_carbon_energy_and_feedstock_for_the_European_chemical_industry.pdf [last accessed on 9 September 2026]

Damania, R., Ebadi, E., Mayr, K., Russ, J. & Zaveri, E. (2025). *Reboot development: The economics of a livable planet*. World Bank, Washington, DC. https://doi.org/10.1596/978-1-4648-2271-1

Dasgupta, P. (2021). *The economics of biodiversity: the Dasgupta review*. HM Treasury. https://assets.publishing.service.gov.uk/media/602e92b2e90e07660f807b47/The_Economics_of_Biodiversity_The_Dasgupta_Review_Full_Report.pdf [last accessed on 9 September 2026]

European Chemical Industry Council (Cefic). (2025). *Industry data. facts & figures of the European Chemical Industry: 2025 Facts and Figures*. https://cefic.org/facts-and-figures-of-the-european-chemical-industry/ [last accessed on 9 September 2026]

European Commission. (2021). *Comission Staff Working Document: Digital solutions for zero pollution*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52021SC0140 [last accessed on 9 September 2026]

European Commission. (2023). *Transition pathway for the chemical industry* (First edition). Publications Office of the European Union. https://doi.org/10.2873/873037

European Commission. *Chemicals strategy: The EU's plan for a toxic-free environment.* https://environment.ec.europa.eu/strategy/chemicals-strategy_en [last accessed on 9 September 2026]

European Commission. *Circular Economy: The EU aims to transition to a circular economy for a cleaner and more competitive Europe*. https://environment.ec.europa.eu/strategy/circular-economy_en?prefLang=de [last accessed on 9 September 2026]

European Environment Agency; European Commission. (2025). *Zero pollution monitoring and outlook 2025*. Publications Office. https://doi.org/10.2800/6470682

Eurostat. (2026). *Enterprise statistics by size class and NACE Rev. 2 activity (from 2021 onwards).* https://doi.org/10.2908/SBS_SC_OVW

Eurostat. (2026). *Final energy consumption in industry – detailed statistics: The highest industrial energy consumers in the EU*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Final_energy_consumption_in_industry_-

_detailed_statistics#The_highest_industrial_energy_consumers_in_the_EU [last accessed on 9 September 2026]]

Garmendia Aguirre, I., Abbate, E., Bracalente, G., Mancini, L., Cappucci, G. M., Tosches, D., Rasmussen, K., Sokull-Kluettgen, B., Rauscher, H. & Sala, S. (2025). *Safe and sustainable by design chemicals and materials: Revised framework (2025)*. Publications Office of the European Union. https://doi.org/10.2760/5103785

German Environment Agency (UBA). *Chemikalienleasing*. https://www.uba.de/n34974de [last accessed on 9 September 2026]

German Environment Agency (UBA). *ChemSelect – assessing the sustainability of chemicals*. https://www.uba.de/n116748en [last accessed on 9 September 2026]

Harremoës, P. & Gee, D. (2001). *Environmental Issues Series: Bd. 22*. *Late lessons from early warnings: the precautionary principle 1896 - 2000*. Office for Official Publ. of the European Communities; European Environment Agency. http://publications.europa.eu/en/publication-detail/-/publication/29ea42f0-28e2-42c0-97a0-aa4923cb80df [last accessed on 9 September 2026]

International Sustainable Chemistry Collaborative Centre (ISC3). *Climate Action Programme for the Chemical Industry – CAPCI: Strengthening the contribution of the chemical industry to climate protection*. https://www.isc3.org/page/capci [last accessed on 9 September 2026]

International Sustainable Chemistry Collaborative Centre (ISC3). *Key characteristics of sustainable chemistry*. https://www.isc3.org/page/key-characteristics-of-sustainable-chemistry [last accessed on 9 September 2026]

Kosmol, J., Jander, W., Günther, J., Döscher, K., Nuss, P., Kahrl, A., Kitazume, C. & Taubert, M. (2025). *Zirkuläres Wirtschaften als Beitrag zur nachhaltigen Entwicklung in unsicheren Zeiten*. Umweltbundesamt. https://doi.org/10.60810/openumwelt-8085

Mergner, L., Bovenschulte, M., Wolter, M. I. & Peters, R. (2026). *Lage und Risiken der chemischen Industrie: GWS Discussion Paper 2026/1.* Gesellschaft für Wirtschaftliche Strukturforschung mbH (GWS). https://papers.gws-os.com/gws-paper26-1.pdf [last accessed on 9 September 2026]

Pagel, M., Schultz, K., Pfeiffer, D., Voß-Stemping, Judith, Steinbrenner, Joscha, Lünenbürger, B., Lange, M., Lambrecht, M., Hölting, P., Kleemann, J., Kahrl, A., Balzer, F., Sorg, D., Schwetje, A., Obermaier, N., Purr, K., Werlein, M., Herbener, R. & Weyland, M. (2026). *Bis 2040 Treibhausgase um mindestens 90 Prozent mindern So kann es gehen!* https://www.umweltbundesamt.de/system/files/medien/479/publikationen/2026-08/uba_bis_2040_treibhausgase_um_mindestens_90_prozent_mindern.pdf

Persson, L., Carney Almroth, B. M., Collins, C. D., Cornell, S., Wit, C. A. de, Diamond, M. L., Fantke, P., Hassellöv, M., MacLeod, M., Ryberg, M. W., Søgaard Jørgensen, P., Villarrubia-Gómez, P., Wang, Z. & Hauschild, M. Z. (2022). Outside the safe operating space of the planetary boundary for novel entities. *Environmental science & technology*, *56*(3), 1510–1521. https://doi.org/10.1021/acs.est.1c04158

Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S. E., Donges, J. F., Drüke, M., Fetzer, I., Bala, G., Bloh, W. von, Feulner, G., Fiedler, S., Gerten, D., Gleeson, T., Hofmann, M., Huiskamp, W., Kummu, M., Mohan, C., Nogués-Bravo, D., . . . Rockström, J. (2023). Earth beyond six of nine planetary boundaries. *Science advances*, *9*(37), eadh2458. https://doi.org/10.1126/sciadv.adh2458

Rosental, M., Fröhlich, T., Liebich, A., Deprie, T., Hartleif, K. & Schock, M. (2024). *Prozessintegrierte Maßnahmen und alternative Produktionsverfahren für eine umweltschonendere Herstellung von Chemikalien*. https://www.umweltbundesamt.de/system/files/medien/11850/publikationen/140_2024_texte_upchem.pdf

Sheldon, R. A. (2023). The E factor at 30: a passion for pollution prevention. *Green Chemistry*, *25*(5), 1704–1728. https://doi.org/10.1039/d2gc04747k

Stolzenberg, H.-C., Blum, C., Klauk, A., Nuss, P., Vierke, L. & Wieck, S. (2021). *UBA fact sheet thought starter towards chemical intensity: A global, inclusive goal for the sustainable use of chemicals is needed to safeguard both societal wellbeing and earth's life-sustaining capacity*. https://www.umweltbundesamt.de/system/files/medien/1/publikationen/2021-11-24-uba-fact-sheet-thought-starter_towards-chemical-intensity.pdf

The Directorate General for Internal Market, Industry, Entrepreneurship and SMEs. (2025). *Communication from the Commission to the institutions - European Chemicals Industry Action Plan*. https://single-market-economy.ec.europa.eu/publications/european-chemicals-industry-action-plan_en [last accessed on 9 September 2026]

United Nations. (2015). *Transforming our world: The 2030 agenda for Sustainable Development*. https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf [last accessed on 9 September 2026]

United Nations Industrial Development Organization. *The performance based business modell for sustainable chemicals management*. https://chemicalleasing.com/ [last accessed on 9 September 2026]

Verband der Chemischen Industrie e.V. (2026). Chemie & Pharma - Schlüsselbranche für Industrie, Innovation und Transformation: Branchenporträt Juli 2026. https://www.vci.de/ergaenzende-downloads/branchenportraet-2026.pdf [last accessed on 9 September 2026]

ZDHC Foundation. (2026). *Better chemistry for a healthier planet*. https://www.zdhc.org/ [last accessed on 9 September 2026]