Center for the Transformation of Chemistry

CTC FOCUS DAY 2026

Advances in Assessing Sustainable Circular Chemical Economy

6 July 2026 · Leipzig, Germany

CTC's Focus Day brought together researchers, industry representatives, and policy experts to examine how sustainability and circularity are currently measured across the chemical science and where today's assessment methods (LCA, TEA, SSbD, and emerging global frameworks) fall short. The day combined a keynote, three thematic sessions, and a cross-sector panel, with a recurring theme: metrics are proliferating, but data availability, standardisation, and practical usability remain the binding constraints on real-world adoption.

The program covered a wide range of topics focused on rethinking the chemical value chain, including systems thinking, circularity, sustainable process development and manufacturing, data availability and gaps, metrics for assessing sustainability, and the role of guidance and regulatory frameworks. Discussions also highlighted the persistent gap between scientific progress and its translation into measurable, real-world sustainability impact

Dr. Christopher Blum, **German Environment Agency (UBA)**
The Role of Metrics in Sustainable Chemistry Transition
Dr. Blum opened by situating Germany's sustainable chemistry agenda within the broader international landscape, referencing the upcoming Shaping the Chemical Transition summit at UBA Dessau (14 October 2026) and the work of the International Sustainable Chemistry Collaborative Centre (ISC3). As mentioned, while the 12 Principles of Green Chemistry remain a useful theoretical foundation, he argued they need to be actively integrated into holistic sustainability assessment frameworks to move beyond a narrow lens. He pointed to the UN Global Framework on Chemicals (GFC) adopted this year in Geneva, though not legally binding as the closest thing to a comprehensive global definition of sustainable chemistry, structured around strategic objectives, 28 targets, and more than 50 indicators still under development.

He also introduced the EU's Ecodesign for Sustainable Products Regulation (ESPR) and the Digital Product Passport, which will require lifecycle documentation across product groups such as tyres and plastics, and UBA's ChemSelect tool a free assessment app aimed at SMEs and startups to support Safe and Sustainable by Design (SSbD) decisions.

Session 1. Methods and Frameworks for Sustainable Chemistry Assessment

Prof. Christina Dornack, **Technische Universität Dresden (TUD)**
Measuring Sustainability – Sufficiency as an Indicator for Environmental Performance"

Prof. Dornack mentioned that circularity and efficiency alone are insufficient as sustainability strategies. Germany's material footprint of roughly 14 tonnes per capita per year (about 40 kg per

day) illustrates a deeper problem of over-consumption, which she linked to social inequality noting that the wealthiest 10% of the population accounts for roughly half of all emissions. Sufficiency, as a strategy of actively reducing consumption of ecologically critical resources, needs to be assessed at local, regional, and national levels simultaneously. She also flagged the rebound effect as a structural barrier: efficiency gains (e.g. in heating technology) are frequently offset by increased consumption elsewhere, such as growing living space.

Dr. Panagiotis Isigonis, Luxembourg Institute of Science and Technology (LIST)
From Theory to Practice: Implementing Safe and Sustainable by Design Across Bio-based and Advanced Material Value Chains

Dr. Isigonis presented LIST's SSbD-related work, emphasising the importance of early-stage definition of system boundaries, terminology, and data needs. His team combines hazard screening with tiered LCA approaches, supported by public data, in silico modelling, and in vitro New Approach Methodologies (NAMs) to address data gaps. He highlighted that SSbD implementation remains resource-intensive and recommended tiered assessments and stage-gated approaches for practical adoption. He also stressed that while hazard assessment should be a key starting point in sustainable chemical design, effective prioritisation requires robust risk frameworks and consideration of factors such as application needs, scale, and regional context.

Dr. Christopher Oberschelp, ETH Zürich
Insights from the Life Cycle Assessment (LCA) of chemicals, plastics and their feedstocks
Dr. Oberschelp argued that conventional green chemistry metrics are too simplistic to capture the full complexity of LCA, particularly given that ecoinvent and comparable databases cover only a fraction of the roughly 130,000 chemicals currently on the market. His group at ETH Zürich has spent over 15 years building advanced methodologies and an assessment tool for machine-learning-based footprinting using primary data. He couples retrosynthetic pathway prediction with life cycle inventory (LCI) estimation across a network of roughly 17,000 reactions, using real manufacturing data shared confidentially by industry partners. He mentioned that efficiency gains in chemical manufacturing are approaching physical limits for processes such as ethylene and methanol production, and that the sector's carbon intensity is trending in the wrong direction as coal-based manufacturing capacity grows in China. His central recommendation was for stronger regionalisation of energy and resource data to reduce modelling uncertainty.

Session 2. Insights from Industry

Dr. Maximilian Menche, BASF
Roadblocks for the Green Transformation – The Balance Between Pragmatic and Perfectionistic LCA

Dr. Menche brought an industry lens to the standardization debate, illustrated with a striking example: LCA results showing that pyrolysis can deliver lower CO2 savings than simple incineration, depending on system boundaries and assumptions. BASF has invested in automated LCA reporting software to manage this complexity at scale. He identified data availability, inconsistent reporting practices, and unclear terminology as the main barriers to broader adoption and agrees that there is no need for new standards, arguing the field already

has enough competing initiatives and instead needs consensus around the ones that exist. His closing point was a call for balance: LCA needs to be trustworthy without becoming so stringent it becomes impractical, and the transition will require all available technologies rather than picking winners prematurely.

Panel Discussion — Research to Reality: Measuring Impact in Circular Chemical Transformation

Panelists· Prof. Liisa Rihko-Struckmann (Max Planck Institute for Dynamics of Complex Technical Systems) · Prof. Stefanie Meilinger (Hochschule Bonn-Rhein-Sieg) · Prof. Henning Friege (N3 Sustainability Consulting) · Dr. Christian Kolbe (ISC3) · Dr. Konrad Gebauer (UPM Biochemicals)

Moderated by Lars Börger, Nova Institute.

The panel converged on a shared message: perfect data will never arrive, so sustainability assessment has to work iteratively with what is available. Panelists agreed that LCA training needs to build real understanding rather than treating tools as a "push-button" exercise, and that early screening assessments should be used to guide direction before deeper analysis is justified. Several speakers highlighted the risk of optimizing one metric at the expense of another for example, reducing dust emissions can increase CO2 output and pointed to the EU taxonomy's "do no significant harm" principle as a useful systems-thinking template.

From a policy perspective, it represents a major achievement, aspiring towards a climate-neutral, zero-pollution, sustainable, circular and inclusive economy. These global developments inspired rich discussion among chemists on reducing the impacts of chemical synthesis and how the chemical sciences can address pressing societal challenges. However, the evolving focus from environmentally green to circular to a more holistic vision of sustainability, along with various frameworks, principles, and metrics introduced, can leave researchers, educators, policymakers, and entrepreneurs unsure how to streamline efforts to accelerate the development and adoption of sustainable chemical technologies.

Notable threads from the discussion

- Trifluoroacetic acid was raised as a cautionary example of a substance that went unmeasured for years before its impact was understood an argument for broader regulatory coverage of emissions monitoring.
- Mass balance principles were suggested as a practical form of self-control for companies generating their own sustainability data, paired with product passports as a shared reporting foundation.
- On policy: panelists were split on whether new regulation would simplify or complicate the landscape, but agreed that any policy change needs input from academia, industry, and civil society together.
- Company-level benchmarking against internal targets (rather than external absolute thresholds) was raised as a pragmatic near-term approach for the industry.
- Integrating sustainable chemistry in the education and university curriculum as the mainstream subject, not as a standalone part.

Session 3 — The Messy Middle: Complexity, Uncertainty, and Data Gaps

From Assessment to Strategy: Navigating the Transition to a Sustainable Circular Chemical Economy

Dr. Lars Börger, **Nova-Institut**

Dr. Börger focused on the shift from fossil to renewable carbon as the central strategic challenge for the chemical industry, distinguishing between the energy required for production and the "invisible" carbon footprint embedded directly in a molecule. He pointed to carbon capture and utilization (CCU) as the most resilient carbon source available today, with CO2-derived methanol positioned as a potential platform chemical for a renewable chemical industry and mentioned that a full supply chain transformation is financially achievable but would require an estimated €140 billion in investment. With roughly 57% of the EU's energy consumption still reliant on imported fossil fuel, he argued the case for energy independence is now as strong as the sustainability case. On land use, he estimated 10–20% additional land could support renewable energy production without compromising food supply.

Assessing Uncertainty in Future Technologies

Dr. Daniela Pufky-Heinrich, **Fraunhofer Institute for Ceramic Technologies and Systems (IKTS)**

Scaling up Sustainable Technologies: A Scientific Assessment Framework for Industrial Transformation

Dr Pufky-Heinrich focused on the challenges for the scale-up solution, as the technology, which seems sustainable at low TRL how doesn’t stand to the pillars of sustainability when commercial or real high TRL levels are reached, She presented a case study on based on the shutdown of a DOW steam cracker in Böhlen, which disrupted the regional naphtha-to-olefins supply chain for ethylene, propylene, and benzene, showing how quickly future-technology assumptions can break down. Her team's response was a six-step transformation workflow for the Central German chemical network (Schkopau–Leuna–Böhlen), incorporating a CCU-methanol platform and accounting for non-linear economies of scale (a scale-up factor of roughly 0.9) when projecting energy requirements for new production capacity. Her key message was that prospective sustainability assessment is most valuable for energy-intensive technologies specifically, since energy cost is typically the dominant variable and that upscaling assumptions should always be explicitly stated rather than left implicit.

Dr. Jonas Hoffmann — GreenDelta GmbH

From Carbon to Multi-Criteria Decisions: Making Sustainability Assessment Actionable for Circular Chemistry

Dr. Hoffmann presented GreenDelta's open-source OpenLCA platform and its application across green chemistry, circular chemistry, and SSbD design criteria. He mentioned that renewable inputs don't automatically translate to a low carbon footprint once criticality factors tied to the EU's Critical Raw Materials Act are taken into account. On the persistent challenge of sourcing data for speciality chemicals, he proposed the integration of advanced machine learning methods and LLMs and also described promising results from OpenLCA's RETROLCA approach, which

combines retrosynthetic AI tools (AiZynthFinder, ASKCOS) with cheminformatics libraries (RDKit, CIRpy) to predict life cycle inventories where direct data doesn't exist.

Key Takeaways

- No single metric or framework currently captures sustainable chemistry comprehensively the UN Global Framework on Chemicals is the most complete effort to date, but remains non-binding and complex.
- Data availability and quality are the most consistently cited bottleneck across every session
- Trade-offs between metrics (e.g. CO2 vs. dust emissions, cost vs. circularity) require systems-level thinking rather than single-indicator optimization.
- Renewable carbon and CCU-derived methanol are emerging as a credible platform for decoupling the chemical industry from fossil feedstocks, though full transformation carries a significant price tag.
- Using AI and machine learning is a prominent step in the future of automated LCA assessment, though the energy cost associated with it should be considered very early on.
- Industry and research broadly agree that iterative, screening-first approaches are more workable today than pursuing perfect, fully quantified assessments from the outset.