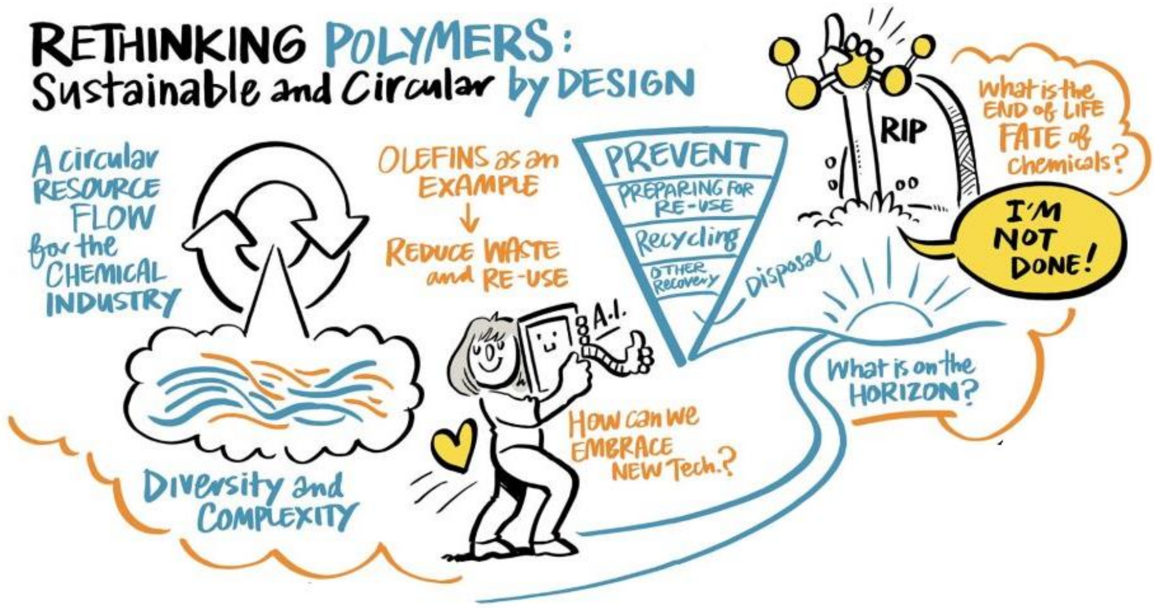
Rethinking Polymers – Roundtable Discussions Report

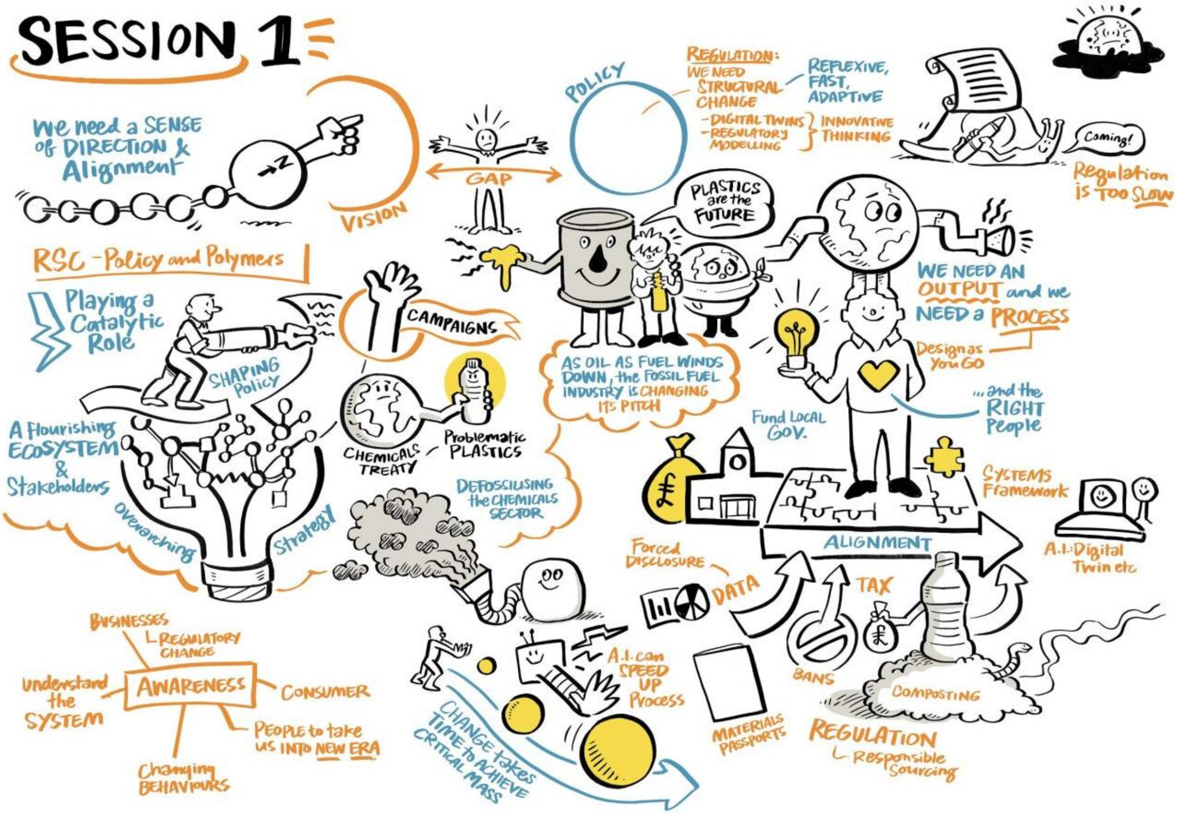


Carbon is embedded in nearly every modern product, not just in the energy used for manufacturing and transportation. While consumers are increasingly aware of the environmental impact of plastics and packaging, the broader origin and fate of carbon often go unconsidered, despite global efforts to reach Net Zero by 2050. To move away from fossil feedstocks, industries must rethink carbon use, keeping it in circulation at its highest value for as long as possible. This requires new methods to trace and account for carbon to meet sustainability goals. Over the past five years, stricter laws have pressured industries to assess their materials' environmental impact, including responsible recycling and disposal. These challenges also present opportunities for innovation and new businesses.

The chemical industry is vital to public health and economic growth. In the UK, it is the largest manufacturing exporter, employing half a million people, but faces rising costs and supply chain restrictions. Operating within a global supply chain, it must adapt to evolving regulations and shifting incentives. Growing consumer awareness is driving demand for transparency in sustainability claims. Replacing fossil-derived chemicals is difficult due to their specific performance requirements. Transitioning to sustainable alternatives will require innovation in technology, testing, data collection, transparency, business models, and workforce skills. The chemical industry is not one-size-fits-all, it is a highly diverse industry with thousands of different chemicals, regulations, and applications. A realistic strategy is needed which recognises sector-specific challenges. Meanwhile, Industry, NGOs, and academia must find common ground despite competing agendas.

On November 18th, 2025, the UKRI Interdisciplinary Centre for the Circular Chemical Economy hosted the Rethinking Polymers: Sustainable and Circular by Design event at the Royal Society of Chemistry, Burlington House in London. The event was supported by the Royal Society of Chemistry, Innovate UK, and IChemE and featured three sessions with presentations and discussions on the future of sustainable polymers. Attendees included a balanced mix of academic and industry professionals, covering: Critical messages for the government; Tools required for industry preparedness; Future funding and research investment needs. Participants were divided into eight discussion groups, mixing representatives from academia, NGOs, and industry to ensure a well-rounded conversation across different sectors. This report highlights the key actions needed to design chemicals for circularity, with a focus on the end-of-life fate of carbon-based materials.

Policy and Government Incentives:



Through these roundtable discussions, participants highlighted changes they would like to see in the policy and regulations sector, identified gaps, and proposed future developments that would aid a more sustainable future. Despite several welcome interventions (such Scotland's 2024 Circular Economy Bill), the policy landscape is still perceived as complex, fragmented and in need of better organisation. Existing actions were deemed insufficient or inefficient and urgent cross-government action and collaboration (between the Treasury and the Departments for Energy and Net Zero, Environment, Food & Rural Affairs, Business & Trade and Science, Innovation & Technology) were called for. For example, Government procurement mandates could create opportunities by creating demand that would then incentivise the scale up and adoption of new technologies. The UK's Government Buying Standards already establish mandatory sustainability criteria for public sector procurement across various sectors, including cleaning products, electrical goods, and furniture. Mandates on recycled content were perceived to help businesses by providing more certainty, reassure investors in technology for sustainable materials and design and ultimately drive down the cost of sustainable carbon materials. Scalable benefits of mass balance approaches were highlighted, particularly while the supply chain for non-fossil feedstocks is becoming established. Extra assistance for small and medium-sized enterprises (SMEs) with limited resources to enable them to invest in sustainable materials and technologies was recommended.

Rethinking Polymers – Roundtable Discussions Report

Measures and Standards:

Tools such as digital twinning and mass balance chain of custody provide opportunities to drive forward the move away from fossil feedstocks. The Department for Business and Trade's plans to introduce legislation enabling digital labelling across various product regulations was viewed favourably. Accounting for end-of-waste in assessments to promote circularity is important. Aligning diverse industries and international regulations is difficult, and the requirements and implementation of sustainability measures can be misunderstood. Standardisation and training to support the validation and assurance of new technology or value chains is necessary.

The EU has established standardized methods for assessing the biodegradability of plastics, such as the EN 17417:2020 standard. Full life cycle and biodegradability assessments should be understood, included in directives (e.g. Ecodesign) and considered by stakeholders throughout the innovation cycle. Better quality and sharing of data for sustainability assessments (such as lifecycle inventories) is needed for accurate assessments. It was perceived that larger businesses hold such data but smaller enterprises may be at a disadvantage. There is some appetite for a government-backed system of auditing LCA with an accurate data system. Concerns were raised over the requirements for REACH registration of polymers, which would demand extensive data on polymer properties, uses, and potential hazards, which could be resource-intensive to compile. Standards and capacity for measuring environmentally meaningful biodegradation that are appropriate for a range of polymers, exposure pathways and different environments polymers end up are currently missing or inadequate.

There was consensus that the UK has an opportunity to demonstrate leadership in these areas if certain barriers were addressed. The UK National Data Strategy does not specifically address Digital Product Passports for chemicals. Its focus on improving data accessibility, quality, and sharing, however, establishes a conducive environment for the development of the tools discussed in this session. It could provide leadership in data governance for enhancing product transparency and sustainability in the chemical industry.

Rethinking Polymers – Roundtable Discussions Report

Research and Innovation Requirements

A shortage of economically viable technologies was highlighted as a major hurdle to retaining the value of polymers. Consistent curbside collection, sorting, cleaning and recycling infrastructure, which require investment, and strict incentives/penalties for not incinerating valuable ‘waste’ streams are needed. Often polymers reach the market as blends or composites and many are used in formulated products which end up in waste water. Energy is a major concern, from cost of energy to steering away from energy recovery from waste. Another major challenge is the issue with cross contamination of polymer types and separation processes. For valorising waste, there are challenges around coproducts and biproducts which also must meet “end of waste” requirements. Meanwhile it is difficult to guarantee feedstock supply from bio-based or recovered feedstocks, whereas fossil is just a single guaranteed source. Large-scale recycling facilities for municipal waste have failed due to process engineering issues. It was recommended that skilled people from the oil and gas industry with experience in large scale processes should be signed up. Pilot plant data is important for proving concepts and collaborations (like Nova) with civic partners can support this.

It was proposed that further, focused, stakeholder forums should agree actions to address the identified challenges and opportunities as a community, drawing on relevant current regulation/policy, leading to public lists for prioritisation. Action as a community is essential to address complex challenges, support consumers to choose more sustainable products and inform policy. The UK Alliance for Sustainable Chemicals and Materials (UK-ASCM), a newly formed advocacy group for the chemical sector, recently championed the 'Sustainable Chemicals & Materials Day’. Greater awareness of industry challenges could ignite new ideas and action in the academic community. This increased awareness should be augmented with R&D investment.

Rethinking Polymers – Roundtable Discussions Report

Key Recommendations:

Actions for Academia:

- Build upon existing reference standards to develop advanced, material specific biodegradation tests that are fit for purpose in real world environments.
- Develop appropriate reference materials for biodegradability testing to generate consistent and comparable data and benchmarks across different industries.
- Enhance analytical tools which improve tracking, validation and assessment methods for material degradation and life cycle impact.
- Support the training and reskilling of the workforce required to meet the needs of sustainable products regulations and to exploit digital tools.

Actions for Industry:

Data Quality and Availability:

- Partner with instrument manufacturers, the British Standards Institution and regulatory bodies to harmonise biodegradability testing and analysis, to ensure repeatability, reproducibility, and robustness.
- Incentivise and facilitate data sharing to enhance LCA and carbon accounting, traceability, and verification of sustainability claims, for example in digital product passports.
- Use dynamic LCA models to guide decision-making and design from prototype to scale-up.

Transparency to Consumers:

- Clearly communicate the environmental impact of products, not through generic sustainability claims, but with verified data.
- Adopt product design to consumer behaviour and recycling infrastructure, to improve alignment with waste hierarchy.

Actions for UK Policy Makers and Funders:

Digital Product Passports and Sustainability Standards:

- Ensure OECD testing methods for biodegradability of polymers are realistic and enforceable in industry settings.
- Extend biodegradability criteria to account for chemicals that reach their end-of-life in aqueous environments, to prevent contamination of water streams.
- Set clear transition timelines for industries adapting to biodegradation and circular economy requirements, balancing urgency with feasibility, in alignment with the Sustainable Carbon Ambition.
- Strengthen the Government Buying Standards and introduce a government-backed LCA certification system to standardize assessments and ensure credibility of sustainability claims.

Research & Infrastructure Investment:

- Fund waste processing and feedstock recovery infrastructure to support large-scale circular economy initiatives.
- Develop a national feedstock strategy to ensure secure, sustainable sourcing and prioritisation of raw materials for chemicals and fuels.
- Establish a Centre of Excellence dedicated to biodegradation measurement, carbon accounting, and value chain analysis to support business and innovation.

Actions for Government & Industry Collaboration:

Targeted Incentives & Support Mechanisms:

- Level the playing field vs. fossil-based incumbents via further tax reform to support UK companies transitioning to alternative, low-carbon feedstocks.
- Align procurement policies with sustainability goals—government contracts should prioritize suppliers using verified circular materials.
- Direct funding towards SMEs developing cutting-edge sustainable materials and chemical innovations.

Smart Policy & Regulation Development:

- Assign an independent industry taskforce to consolidate policies across different government departments, ensuring a cohesive regulatory framework rather than fragmented, competing rules.
- Integrate the create a clear roadmap for sustainable transformation of the Chemicals Industry and aligned sectors.
- Develop sector-specific policies rather than a one-size-fits-all approach to chemical regulation.

Call to Action
Explore opportunities to progress key recommendations through the Circular Economy Taskforce
Policies should be consolidated across different government departments and ensure a cohesive and well-structured regulatory framework instead of fragmented, competing rules. It should provide an independent voice to ensure that Circular Economy practices can be implemented, standardized, and enforced without preventing the UK Chemical Industry to thrive in a global market. It should work with stakeholders to develop a skills plan to enable businesses to be competitive in a rapidly changing and challenging landscape.
https://www.gov.uk/government/groups/circular-economy-taskforce

Deliver greater data governance, quality and sharing to fully exploit digital tools that help businesses track, manage, and optimize the flow of materials throughout a product's lifecycle. Industry should be supported in providing data for Digital Product Passports that verify sustainability credentials and support traceability through national infrastructure and standardisation. **A Centre of Excellence** which combines existing assets to deliver standardized, credible, certified assessments for sustainable materials would provide the capacity to go faster in meeting smart regulations.

Explore opportunities to leverage funding already committed for example, under the Ofwat Innovation Fund to help the water sector innovate https://waterinnovation.challenges.org/

BOX 1: POLICY GOOD PRACTICE

Wales: Over the past 20 years over £1 bn has been allocated to help local authorities invest in recycling collection services. Developments in recycling infrastructure, along with consumer awareness campaigns, and legally binding targets have propelled Wales from having one of the lowest municipal recycling rates in the EU (5%) to second globally.

Scotland – "Circular Economy (Scotland) Act" (2024): This Act mandates a Circular Economy strategy, with measures to reduce waste, modernise recycling services (building on the £70 m Recycling Improvement Fund), and promote resource reuse. These include recycling targets, restricting disposal of unsold goods and fees on single-use items.

Northern Ireland – adoption of EU's "Ecodesign for Sustainable Products Regulation (ESPR)" (2024): This framework legislation allows the government to set requirements for sustainable products, including making these more durable, reparable, recyclable, and energy and resource efficient. A three-year plan (due 2025) will also detail the products to be regulated under ESPR, such as textiles, paints, and chemicals, among others. ESPR outlines the mandatory requirements for product exports to the EU.

Ireland: Waste collection in Ireland is managed by private waste collection companies, which charge residents for waste disposal services, with the Irish government regulating waste management practices. Many private companies use a pay-as-you-throw system, designed to incentivize recycling and waste reduction. Killarney became the first town in Ireland to implement a voluntary ban on coffee cups (See **Community Incentives**, page 8).

Germany – "Pfand" system: This consumer-based initiative has resulted in a plastic container return rate of over 98%. A deposit fee (Pfand) is added to the price of the products for their containers at the point of sale and is refunded to consumer when containers are returned to designated collection points, creating an incentive for consumers to recycle.

Sweden – "Circular Economy – Strategy for the Transition in Sweden" (2020): Covers production and product design, consumption and use, non-toxic and circular material cycles, as well as measures to promote innovation and circular business models. The strategy was followed by a circular economy action plan, an action plan for plastics and a national waste management plan and waste prevention programme. The Swedish "pant" system is a recycling program that encourages people to return empty beverage containers for a refund.

South Korea: Prohibiting food waste going to landfill since 2005 has resulted in increased food waste recycling rates, from 2% (1995) to 95% (2019). South Korea's Weight-Based Food Wastes Fee (WBFWF) system (2013) and policies for developing food waste recycling infrastructure, has made it a global leader, with a highly effective composting system.

China – "Zero-Waste City Pilot (ZWCP) Policy" (2019): This is a city-level environmental regulation aimed at driving China's green and low-carbon development. In 2019, the ZWCP reform was launched in "11 + 5" cities and regions, as part of the during the 14th Five-Year Plan Period. Since then, almost 100 cities have joined the pilot program.

USA – USDA's BioPreferred programme: mandatory purchasing requirements for federal agencies and their contractors, and a voluntary labelling initiative. **EPA's Safer Choice programme:** voluntary labelling initiative, to help consumers identify sustainable products with safer chemical ingredients without sacrificing quality or performance

BOX 2: ADVOCACY GOOD PRACTICE

NGOs, Trade Associations and Professional Institutions

By unifying networks to enhance communication and collaboration, drawing inspiration from organizations like the International Union of Pure and Applied Chemistry (IUPAC) which have successfully operated at scale over time, the chemical industry can establish a cohesive policy framework with a unified voice. Such a network would bolster lobbying efforts for sustainable policies and regulations at the governmental level, to meet the needs of the UK chemical industry. Many organisations have already contributed resources, reports, and recommendations. Some examples include:

- **Royal Society of Chemistry (RSC):** "Catalysing change: Defossilising the chemical industry" (2024); "The PLFs Revolution: Our 2040 roadmap for sustainable polymers in liquid formulations" (2023).
- **Henry Royce Institute:** "The Life Cycle Assessment Regulatory Science and Innovation Network (LCARSIN)" - developed to help the foundation industries reduce their environmental impact by using LCA. The "National Materials Innovation Strategy" describes how materials innovation improves product sustainability, durability and efficiency, ensuring they meet the demands of a circular economy.
- **Waste Resource Action Programme (WRAP):** "UK Plastics Pact Target Delivery Roadmap" (2024).
- **British Plastics Federation (BPF):** "Recycling Roadmap 2nd Ed." (2024).
- **Institution of Chemical Engineers (IChemE):** "Barriers to Industrial Decarbonisation" roundtable discussion (2024).
- **The Sustainable Chemicals and Materials Manufacturing (SCHEMA) Hub: "**Sustainable Chemicals & Materials Day" (2024); "Challenge Workshop: Sustainable Polymers and Elastomers" (2025).
- **UK Alliance for Sustainable Chemicals and Materials (UK-ASCM):** newly formed advocacy group for the chemical sector.

Community Initiatives

Business and community-driven initiatives can have an important role to play in the transition to a circular economy, by empowering individuals to adopt more sustainable practices and putting pressure on businesses and government to act. The "**Killarney Cup Campaign**" is a business pact among cafes and coffee shops to ban disposable takeaway cups, which made Killarney (Ireland) the first town in the EU to phase out single-use coffee cups. The well-known app "**Too Good To Go**" aims to reduce food waste by advertising surplus food offered by restaurants, bakeries, and supermarkets at affordable prices.

BOX3: EXPLAINER

Circular, Sustainable or Renewable? While circularity focuses on returning of material to use to reduce waste, sustainability focuses on improving the efficiency with which natural resources are used. Although principles of circularity and sustainability often supportive they are not necessarily interchangeable, with energy-intensive recycling processes being one example of unsustainable circular practices. Similarly, renewable or 'bio-based' chemicals, which are derived from renewable resources, may or may not be circular or sustainable depending on their lifecycles and the available alternatives.

Circular Economy: The EU defines the circular economy as, "a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible." By maximizing value, waste and overall environmental impacts of products and materials are minimised. In the context of the chemical industry, a shift from a linear to a circular model is expected to result in reduced demand for both fossil and renewable primary feedstocks.

Waste Hierarchy: A framework for prioritising waste management options, in order of their environmental impact. It prioritises the prevention of waste creation, while disposal options, like landfill and incineration without energy recovery, are given as a last resort measure. The steps and definitions are set out and made legally binding in the revised Waste Framework (Directive 2008/98/EC). These are prevention, preparing for re-use, recycling, "other" recovery and disposal.

Defossilising vs Decarbonising: Polymers like plastics and lubricants are carbon-based materials, making them inherently impossible to decarbonise. Rather, the focus must be on defossilising by switching from fossil to advanced feedstocks, derived from solid waste, captured carbon dioxide or biomass, and decarbonising the energy used in their manufacture. This requires large scale availability of these feedstocks for the production of secondary raw materials, like pyrolisis oil, to a quality that is compatible with available infrastructure. The **Sustainable Carbon Ambition** report promotes a **Best Available Carbon** principle, integrating multiple carbon sources based on feasibility and environmental impact.

Life Cycle Assessment (LCA): LCA is a method for assessing the environmental impacts of a product, process, or service. Cradle-to-gate LCA includes all the stages of a product's lifecycle, from the extraction and processing of raw materials, its manufacture, distribution and use, through to disposal. By assessing the material and energy inputs and environmental releases at each stage, LCA evaluates the cumulative potential environmental impact. International standards for conducting LCA are set out in ISO 14040:2006 and ISO 14044:2006. This includes guidelines for determining appropriate system boundaries which, along with determining baselines for comparison, are an essential part of LCA. Dynamic LCAs which account for variations in parameters that may occur over time, such as changes in the electricity mix due to increased renewable energy capacity, offer greater accuracy.

Mass Balance: A method for accounting for the material flow through a system or supply chain. It provides a direct physical link across the value chain, as opposed to other methods such as "Book and claim" in which sustainable materials or certificates are separated from the physical supply chain.

Digital Twins: A form of advanced modelling, using a virtual representation of a physical asset, that provides real time updating and automatic dataflow between the digital and physical asset. Digital twins can be used for equipment, process, systems, and whole supply chains.

PET and Terephthalic acid: Poly(ethylene terephthalate), or PET, is one of the most widely used polymers, found in products like plastic bottles and polyester textiles. The bio-based production of its constituent ethylene glycol is an established process, with large-scale production from biomass. However, bio-based pathways for terephthalic acid, which accounts for the remaining 70% of PET by mass, are still unable to compete with fossil-based production on both cost and efficiency. Other aromatic diacids are widely used to produce materials such as powder coatings, used in applications that require properties like hydrophobicity, elasticity, and high glass transition temperatures.

Polymers in Liquid Formulations (PLF): These are polymers that are used in formulations that are liquid during manufacture or use, such as thickeners, emulsifiers, and binders. PLFs are found in a diverse range of household and industrial products, from cosmetics to flocculants used in wastewater treatment. The end-of-life fate of PLFs is a particular challenge to their circularity and sustainability, as they are likely to be released into the environment through wastewater resulting in value loss and potential harm from accumulation or their degradation products.

BOX 5: CASE STUDIES - FUNDING

IUK Business Connect

Innovate UK Business Connect has provided £60m in funding to over 5000 Innovators, with projects spanning a range of innovation themes. These include: Return/Refill (e.g. Abel & Cole), Biobased feedstock (e.g. Notpla, Xampla), depolymerisation techniques (e.g. Mura hydrothermal, Versalis, Greenback, Sylatech, Longworth), mechanical recycling (e.g. Berry, Impact recycling) and AI projects (Plastic-I, Polytag, PEN3P, Recycle-I).

BOX 6: CASE STUDIES – DATA and TRACKING

ChemCycling® – BASF

BASF's mass balance portfolio features over 1,500 certified products, ranging from food packaging to medical, textiles, and automotive. These biomass-balanced and Ccycled® products are identical to conventional products but have a lower carbon footprint and are derived from circular feedstocks. Third-party certification, according to internationally recognized third party certification schemes like REDcert[2] and ISCC PLUS and meet the definitions by ISO 22095:2020, ensures the correct substitution of fossil resources through recycled or bio-based feedstock is made. BASF's ChemCycling® uses pyrolysis of plastic waste or end-of-life tires to generate pyrolysis oil which is fed into BASF's Verbund production at the beginning of the value chain. Through biomass balance and ChemCycling®, fossil raw materials in BASF's complex production network can be replaced in a flexible way with a range of circular feedstocks, which also enables rapid scaling as customer demand increases.

PolyTag

Polytag technology utilises invisible UV label tags that can be detected at connected recycling centres with installed Polytag UV Tag Reader systems. The 16mm x 16mm digitally printed 2D UV tags are applied during the standard plate printing label process, consisting of a GS1-approved 'unique-every-time' digital link QR codes. This system allows brands to monitor their product packaging lifecycle information, from production through to recycling, providing real-time data such as recycling rates and consumer interactions. Polytag have partnered with major retailers like Co-op, Ocado and Aldi UK and are looking to support businesses with upcoming legislation such as the EPR and DRS.

BOX 7: CASE STUDIES – WASTE PROCESSING

Mura Technology: HYDRO-PRT

Hydro-PRT is a hydrothermal plastic recycling technology that uses supercritical water (water under elevated pressure and temperature), to convert hard-to-recycle plastic waste into hydrocarbons, providing an alternative to fossil feedstocks. This process yields a range of products; naphtha and distillate gas oil for plastics; heavy gas oil for chemicals, oils, speciality plastics and wax; and heavy wax residues for asphalt or bitumen production. Hydro-PRT, unlike traditional pyrolysis, does not require pre-dried feedstock and does not produce unwanted by-products like char. The direct contact between plastic and supercritical water allows for highly efficient heat transfer, simplifying scale-up. Mura Technology are developing sites in the UK, Europe, USA and Southeast Asia, and licence their technology globally. It's first facility in Wilton, Teesside, is expected to be operational in 2025 and will produce 20 kt liquid hydrocarbons annually, supplied to Dow and Neste.

DeepTech Recycling

UK-based chemical recycling technology firm that focuses on pyrolysis treatment of hard-to-recycle plastic waste and monomer recycling including styrene recovery from polystyrene.

R&D Hub for Plastic Waste Processing

This initiative brings together 7 industry leaders —BASF, Covestro, Dow, LyondellBasell, Mitsubishi Chemical Group, SABIC, and Syensqo to collaborate on developing low-carbon waste processing technologies to tackle challenges in plastic recycling. The R&D Hub was born out of an initiative by the GIC under the World Economic Forum and now managed by the Dutch independent research organisation TNO. Its projects fall under the themes: "Sensing for sorting", "Polymer/inorganics separation at micrometre scale", "Enhanced solvolysis for composite recycling", "Polymer/inorganics separation at millimetre scale"

BOX 8: CASE STUDIES – RETURN and REUSE

Loop – Tesco

Loop was a reusable packaging initiative launched by Tesco in partnership with TerraCycle's Loop platform. Introduced in September 2021, the program aimed to reduce single-use packaging by offering products in durable, returnable containers. Customers could purchase over 80 products, including well-known brands like Persil, Carex and Tetley, as well as 35 of Tesco's own-label items, in reusable packaging. After use, they would return the empty containers to designated in-store collection points, where the packaging would be cleaned, refilled, and restocked. Despite positive customer feedback, the trial concluded in June 2022. Tesco is now evaluating insights from the trial to inform future sustainable packaging solutions.

Abel & Cole

Abel & Cole has pioneered various reuse initiatives. Their carboard Returnable Delivery Boxes average five to six deliveries each and use reusable wool from Woolcool® to insulate perishable products. The Club Zero Refillable Service offers a range of products in reusable packaging, like refillable milk bottles made from 100% polypropylene. These can be refilled up to 16 times before recycling, significantly reducing the carbon footprint compared to heavier traditional glass bottles. They also launched a doorstep recycling service, “Plastic Pick-Up”, which collects flexible plastic waste for recycling into materials for the construction industry.

GoUnpackaged

GoUnpackaged is a UK consultancy specialising in reuse & refill, helping brands reduce their single-use packaging and transition to reusable packaging, in a smooth and cost-effective way. GoUnpackaged conduct research into the commercial, operational and environmental impact of reuse. One insight from the 2022 “Reusable Packaging Roundtables”, in collaboration with Wrap and the UK Plastics Pact, was that more research and innovation are needed around packaging standardisation. This could include standardised apertures and filling equipment to reduce cost and complexity during reuse. GoUnpackaged’s Refill Coalition is a cross-sector collaboration project which aims to expand in-store and online refill offerings. It developed a standardised bulk reusable vessel, for both dry goods and liquids, with an optimised design for the supply chain and available for use by any supplier. Funded by Innovate UK, the project launched in October 2023, in partnership with Aldi and Ocado, as well as logistics experts CHEP.

BOX 9: CASE STUDIES – PRODUCTS

Xampla

Xampla's Morro™ materials are made from extracted plant polymers, with no chemical modification. They are fully biodegradable, home compostable and compatible with standard recycling processes. Its range of products include Morro™ coating, soluble film, edible film, and Micro, an encapsulant for active ingredients in personal care products, fragrances, and agrochemicals. Morro™ coating is heat sealable and has grease, water, and oxygen barrier properties, designed for use in foodservice and FMCG packaging. Being plastic-free, it is exempt from the Single-Use Plastic Directive and the Plastic Packaging Tax. Partnering with Gousto, Xampla developed an edible stock-cube wrapper made from plant protein, designed to protect the product during transport and storage but dissolve on cooking.

Notpla

Notpla make compostable a 100% natural seaweed coating that is not chemically modified, making it exempt from the EU's Single-use Plastic Directive. Seaweed is an abundant, quick-growing resource that sequesters carbon and does not require freshwater, land or fertiliser. Notpla packaging has is robust, with a leakproof coating, resistant to water and oil. Its liquid packaging allows liquid encapsulation in a thin, flexible and edible layer. Notpla materials are biodegradable and recyclable, through home composting or standard paper waste recycling streams as they are EN13430 compliant. It will biodegrade in the environment if littered.

ReBorn

ReBorn is a recycled homeware brand made in the UK from 100% local recycled plastic industrial waste, such as polypropylene and TPE, together with metals such as stainless steel. Independent LCA analysis, found that the Reborn washing bowl provide a 79% reduction in lifecycle carbon emissions when compared with an equivalent product made from virgin materials in the Far East. ReBorn products are designed to be circular, being reusable, repairable and recyclable at end of life. Using single materials, instead of "co-moulding", to be easily recyclable at many Household Waste Recycling Centres (HWRCs). Their range of kitchen and bathroom products, such as soap dispensers and washing up bowls, are available at John Lewis.

Rethinking Polymers – Roundtable Discussions Report

Policy Challenges:

Lobbying and Collaborative Efforts for Policy Change:

The first session focused on the policy and regulations landscape of polymers, and included perspectives on upcoming changes, highlighting good practices, required developments, as well as thoughts on sector and consumer awareness. There are major challenges to meeting the urgent need for action, in the context of a complex sector.

Participants agreed on the importance of a UK strategy for the chemical industry, highlighting the urgency of transitioning the sector to ensure that it is retained and aligns with our net zero obligations. The Chemicals Strategy led by DEFRA aligns with net-zero and circular economy goals, but its publication has been delayed. Participants mentioned the need for this to account for the diverse and complex nature of chemicals and materials, particularly for regulatory purposes. Throughout the roundtable discussions, the matter of urgency and quick government action was a consistent thread.

Government and ministers need clearer instructions and roadmaps which include a clear economic case to direct policy change. Bold leadership and vision are required, with an "industry champion" lobbying for sustainable policies and regulations. The challenge of uniting industry, NGOs, and academia, who have conflicting priorities, under a single voice was noted. Participants highlighted the importance of fostering collaboration, prioritizing common goals, and compromising over competing agendas. They called for a cohesive policy framework and improved global communication to enable a coordinated overarching policy, though this was acknowledged as a complex undertaking.

Addressing the complexity of cohesively organizing current and upcoming legislation and policies, will likely require extensive cross-departmental work. Therefore, a major task of the CE taskforce will be ensuring that government departments are not working in silos. This includes work to comply with UK regulations, such as UK REACH and UK Environment Act 2021, and those of our international export markets.

Discussions on a collaborative chemical strategy raised several critical questions: *How should chemicals be defined? Where should boundaries be set? How can the diverse and varying needs of chemicals, each with distinct requirements, be addressed?* The Chemicals and Materials sectors are highly complex and interconnected, with a vast range of materials, processes, products, and end-use cases, as well as associated supply chains. This means that the upcoming Chemical Strategy, and any policies and regulations, must take the form of a detailed framework that integrates all sector-specific requirements from production through to end-of-life, rather than a one-size fits all approach. This is especially important when competing interests exist—for example, between sustainable aviation fuel (SAF) and chemicals. The proposed strategy would need to move away from the status quo, reflecting a future dispersed circular model that emphasizes coordination, connection, and long-term sustainability.

A successful Chemicals Strategy could create economic opportunities from systematically tackling materials, resources and waste, and drive investments in new technologies. Addressing circularity and materials requirements, such as safety, durability, recyclability, and end-of-life valorisation, could foster innovation, create new value streams, and give the UK a competitive edge.

Legislation:

There was a perception that the UK's Circular Economy Package (CEP), aligned with Environment Act 2021 and Resources & Waste Strategy, which legally mandates waste minimization and recycling measures, does not go far enough with regards to a circular economy model for chemicals. Extended Producer Responsibility (EPR) regulations, covering materials use and end-of-life considerations for plastics and polymers, could go further to incentivise the adoption of alternative feedstocks for fuels and chemicals. Participants called for more investment in infrastructure to enable waste valorisation at scale, including plastics and CCU, along with a comprehensive feedstock policy. Some groups argued that policymakers should drive down the cost of sustainable materials, advocating for tax incentives for using sustainable materials to drive both supply and demand. Government procurement mandates were also put forward, as these could create opportunities and build new markets. These incentives were perceived as helping reduce business uncertainty associated with investing in sustainable materials and design. It is likely critical to help small and medium-sized enterprises (SMEs) with limited resources to meet sustainability goals. It was perceived that not enough companies are submitting data fast enough to meet the extended producer responsibility (EPR) for packaging data reporting deadlines. Additionally, many SMEs may be unaware of these reporting requirements, leaving them at risk of facing penalties. However, enforcing compliance would require significant resources. Cost was seen as the biggest barrier to transitioning the chemical industry to a circular and sustainable model. Large, localised infrastructure changes are expensive, while novel dispersed modular systems do not benefit from economies of scale. Participants questioned who will fund change of the scale required, drawing parallels to the industrial revolution which was leveraged by private funding.

Discussions also touched on the introduction and enforcement of policy and regulation in the UK. Local authorities in the UK are legally responsible for creating waste collection policies and addressing waste crime like fly-tipping through investigation and removal. However, they have limited powers to shape legislation and insufficient resources to tackle waste crime. As waste levels rise, so do the costs of managing it.

It is unclear whether the UK should aim to lead on policy and regulation, or whether it is better to align with international policies and regulation that are perceived as working well already. Having a dynamic and flexible approach to policy and regulation was perceived as necessary to prevent loopholes and allow for rapid adaptations that may be required in the future. Better practices are needed in enforcing policy and regulations, and greater transparent in documenting success.

The need for harmonised legislation on the classification and testing of specific materials was also discussed, with biodegradability as a focus. Manufacturers will need to prove their sustainability claims to comply with current and upcoming regulations, including product biodegradation metrics. Existing EU and UK biodegradability testing and classification frameworks (such as OECD Test

Guidelines (e.g., OECD 301) and the EN 17417:2020 standard) were viewed as inadequate to meet the requirements of registration and legislation of some polymers. There was a perception that companies could choose tests that give favourable results. In the UK, biodegradation in soil environments is considered but not in water streams. Therefore, attendees identified the need for measures to avoid infiltration of water bodies to meet our environmental objectives. They proposed databases of standard data (e.g. biodegradability of polymers).

Systems Perspectives

The second session tackled how to make polymers industry ready, covering enabling tools including digital twinning, mass balance, chain of custody, life cycle assessment (LCA), biodegradability assessments and analysis of degradation pathways. Data obtained will feed into Digital Product Passports, which the UK and EU are introducing, to demonstrate product compliance with the regulations in export markets, such as the EU's newly introduced Ecodesign for Sustainable Products Regulation (ESPR).

Circularity:

Standardised waste collection would enable the transition to circular feedstocks, while digital waste tracking would provide a comprehensive understanding of our waste and improve compliance with reporting requirements. Feedstock availability is critical, and solutions are also needed to reduce the energy associated with collecting and managing waste. There is currently insufficient plastic feedstock of the right quality for reprocessing (e.g. via pyrolysis oil/cracker), to enable circularity at scale. Continued advancements in waste valorisation technologies, such as chemical recycling and advanced bio-ethanol production are needed. For bio-feedstocks, the UK's limited land area poses a significant challenge, highlighting the need for clear priorities in allocating feedstocks between chemicals and fuels. Additionally, the life cycle of materials including bio-derived chemicals must be carefully assessed, particularly their end of life, to ensure they offer a circular and sustainable alternative to the conventional linear pathways of fossil-derived chemicals. The Definition of Waste is seen as a barrier to achieving circularity, with national and international legislation governing how waste can be treated, including regulations around cross-border waste shipments and limiting reuse of discarded materials. End-of-waste requirements need to be easier to navigate, and obtaining legal advice was perceived to be a cumbersome process.

Sustainability of Design/Supply Chain:

Supply chain regulations need to be progressive to allow local and national infrastructure to adapt. Consideration should be given to the complexity of the product's market, and the regulations and policies that apply or are prioritised. These reforms may be approached from two direction; should it be innovation-led, or should regulation drive innovation? In some cases, more sustainable product design may conflict with current consumer preferences, necessitating stricter regulations to effect change.

Participants observed that the current approach, where companies focus on their individual sustainability goals, fails to foster collaboration. Instead, sustainability should be treated as a holistic challenge with companies unifying their goals across their entire supply chain. This approach needs to be coordinated across all sectors of industry, consumer interests, and policy to create a truly circular economy in the UK. However, harmonising standards across the supply chain may be difficult, with proprietary standards and test and decoupling data from IP being two potential hurdles. A unified approach would also rely on transparent communications between companies and industries.

Transparency to Consumers:

It is perceived that company strategies are mainly driven by consumer demand for sustainable products and reduced carbon footprints, rather than government decisions. Some groups perceived consumers as having "claims of interest" and wanting more sustainable regulation but lacking in real engagement when it came to time, effort, or knowledge. Some perceived that younger consumers were demanding sustainable products but were not the demographic paying for them.

Consumers often face substantial knowledge barriers, a challenge further compounded by ambiguous packaging labels. However, they can be guided and incentivised to adopt better practices, with policy makers playing a crucial role in increasing knowledge on sustainable materials. For example, the voluntary USDA Certified Biobased label indicates that the product has been certified by the USDA to contain the percentage of biobased content shown on the label. The potential of social media, sustainability influencers, should also not be overlooked.

There is a desire for transparency when it came to understanding consumer demand and cultural behaviours around waste and recycling, and how these components influence product design. Some suggested that consumers might push back at complicated recycling systems and advocated for simpler, more accessible approaches. Such strategies could encourage better practices, facilitate scalable communication, and increase participation rates in recycling schemes.

Digital Product Passports and Sustainability Standards:

The chemical supply chain is non-linear, there are branches in and out, so sharing data in a safe, trustworthy, and efficient way is necessary for decision making for life cycle assessments and carbon flow. The importance of LCA was a common thread through many discussions. ISO 14040 and ISO 14044 already provide internationally recognized LCA frameworks, and multiple EU and UK regulatory mechanisms integrate LCAs into decision-making. Data reporting, including lifecycle data, is a requirement for many new regulations, such as Carbon Border Adjustment Mechanisms, Environmental Product Declarations, Digital Product Passports.

It was highlighted that to obtain a holistic and accurate assessment of the sustainability of materials, LCA, along with biodegradability, mass balance and chain of custody for mixed feedstocks are needed, with digital twins to link materials, processes, and supply chains together. Investments could be directed towards projects based on sustainability, based on the outcomes from these assessments. Attendees advocated for adopting LCA as a design aid through all stages of production, from prospective assessment to scale-up and beyond. The participants agreed that LCA requirements need to be integrated within policy, including an LCA framework for end-of-waste to enable circularity.

Discussions surrounded the importance of dynamic LCA, and performing full cradle-to-grave assessments, the importance of performing LCAs correctly, and difficulties surrounding data. LCA methodologies have been used for over 30 years, and employed to issue eco-certificates e.g. Carbon Trust, Blauer Engel, FSC etc. However, there is a general perception that LCA methods and certification are not sufficiently standardised or adopted. While LCA software is becoming more readily available, significant data gaps currently hamper its utility as a design and decision-making tool. Therefore, policy makers and the chemical industry need to work to improve data availability and exchange, particularly between large companies and small companies. Standardising data inputs from different databases, e.g. Ecoinvent and Carbon Minds, and fact checking of datasets and databases is a complex task. Data relevance is another issue; Databases may use global averages when specific regional data is not available, academic data may have limited applicability for industrial-scale processes and LCA is very challenging for new products with limited data. In addition to this, new tools, like LCA, were perceived as difficult for businesses to adopt and develop as they grow and change. However, automation is expected to improve the efficiency of data capture and enable data reporting compliance.

Biodegradability:

Much of the discussion focussed on the barriers in sharing testing methods internationally, particularly between biodegradability testing centres in the EU and Australia. Some groups raised that the standards and methods we have, including the OECD Guidelines for the Testing of Chemicals, are not fit for purpose for current or future materials. Standardised tests are expensive and lengthy (often at least 28 days), using a standardised biome reactor and measuring the carbon dioxide released or the oxygen demand. However, the test conditions used may not be relevant to the environment the material ends up in which is of particular concern for polymers in products like shampoo that reach their end-of-life in different environments. It does not consider what happens to the polymer itself. Participants pointed out that there is a lack of standards and capacity for measuring environmentally meaningful biodegradation in all the possible exposure pathways (dry, wet, hot, cold, etc.). There also appear to be difficulties in accessing facilities and limited resources for undertaking bio-degradation studies for individual samples and molecules, which are very time consuming. Polymer formulations are not often considered. One participant raised that their university laboratory had recently started performing bio-degradation studies (currently non-accredited) because of the demand in requests.

In addition to this, testing and QC need to be harmonised for reproducibility, to ensure that all labs are measuring the same thing. Standard protocols and training for sample preparation, measurement and analysis are needed to ensure the reliability and reproducibility of studies. New tools may be required which would benefit from input from analytical instrument manufacturers. A national measurement system for chemical, biological and physical assessments was called for, building on the existing polymer network.

Good Practices:

Regarding good practices that could be adopted in the UK, discussions highlighted that even post-Brexit, EU regulations continue to heavily influence UK policies. EU mandatory recycling programmes, REACH regulation, regulations on Biomass, and the 2021 plastics tax on non-recycled plastic package waste (charging countries 80 c/kg waste) were mentioned. Sweden, Denmark, Norway and the Netherlands were identified in developing early examples of circular chemical economies.

Rethinking Polymers – Roundtable Discussions Report

Technology/Innovation:

Digital Twinning to Increase Industrial Productivity and Help Achieve Net Zero Obligations:

Digital twins are increasingly being adopted, especially by large multinational chemical companies. They can be a twin of a real asset (physical twin) in real time e.g. an asset, a process or a system (e.g. a supply chain). AI and machine learning approaches could improve the productivity of chemical manufacturing, link to best-use (e.g. through autonomous optimisation if processes in response to the system) renewable power, recycling infrastructure etc. which can be difficult to predict. High costs remain a major barrier to broader implementation. Wider adoption is expected to benefit the chemical industry, however, by optimising operations and enabling collaborative decision-making among various stakeholders. Challenges exist around data availability and data sharing in safe, secure, and ethical ways. Emerging regulations, such as those related to Digital Product Passports, are expected to standardise reporting and provide data records that can used as inputs for digital twins.

Digital twins could be a useful tool for lifecycle and sustainability assessments. However, there are significant data gaps in the end-of-life fate of chemicals and materials which still need to be addressed, particularly for products like PLFs. Digital twins can themselves be used to explore end-of-life pathways and have the potential to accelerate biodegradability testing. For example, digital twins of end-of-life environments, such as wastewater treatment facilities, that simulate the introduction of various materials and mixtures could be used to assess breakdown products under different conditions.

Biodegradability Testing:

Biodegradation tests need to be sensitive to a range of polymers and reflect the different environments they end up in through their lifecycle. A critical aspect of this is understanding the fate of chemicals and materials, such as PLFs, in soils and waterways, considering both the physical and biological conditions of these environments and the geographic boundaries for tests. Some materials may not fully biodegrade in their end-of-life environments and can accumulate along with their degradation products. Possible interactions with formulation components and analytes present in the environment must also be considered. It is essential that end-of-life of materials is properly understood, looking beyond CO_2, to understand underlying degradation mechanisms and establish whether degradation products are safe.

Appropriate reference materials need to be developed, along with new analytical tools and techniques, as well as standards and tests for sustainability and degradation for specific materials and environments. To do so, instrument manufacturers could be engaged, and current reference standards and tests may be used as starting points in developing more advanced metrics. High throughput methods for polymer biodegradation studies, analogous to Platform of Microorganisms Fast Identification (PFI) genetic tests, such as microbial enzyme assays that screen for enzyme activity, could be developed. However, high throughput biodegradation studies on all the materials we need to investigate will be challenging to achieve in the short-term, as will implementing the necessary technology.

Biodegradability is notably not a silver bullet for the sustainability problem. For instance, if CO_2 released during biodegradation is not offset elsewhere in the product lifecycle this results in a net negative impact. Additionally, the broader impacts of polymers must be considered during their design. For example, detergents can significantly reduce the carbon footprint of washing processes and extend the longevity of other products. They can also help keep synthetic fibers intact, thereby preventing the release of microplastics during washing. These considerations underscore the importance of a holistic assessment of sustainability.

Mass Balance:

Mass balance will be essential to transitioning our current overwhelmingly fossil-based chemical industry and enabling net zero. It provides an efficient approach to sustainable production, by gradually increasing the proportion of circular feedstocks used within existing production processes and established pathways. Mass balance provides flexibility as incremental changes are made, such as infrastructure adaptation and changes to the feedstock mix. It enables the transition from fossil carbon to captured carbon feedstocks at different timescales depending on the product.

Mass balance is already used to track materials like timber and fair-trade products and adopted in various certification schemes, such as REDcert. These schemes require audits, which generally assess the input yield and feedstock sustainability for a given booking period. However, not all of certification schemes have mutual recognition.

Participants were not all aware of how widely mass balance is being used in the chemical industry. Companies like BASF, SABIC, and LyondellBasell already use mass balance approaches certified under ISCC PLUS and REDcert. BASF have saved 4.3 mt CO_2 emissions via "Verbund". One hurdle to wider use may be data availability and data sharing. Reliable mass balance depends on accurate inventories across systems and along the supply chain. Data gaps in downstream use and end-of-life remain a huge issue since Companies may not have strong connections with end-of-life operators. Building partnerships with recycling operators to ensure data is captured throughout the recycling process will be important for digital product passports.

Value of Virgin Polymers and its Impacts:

Valorising plastic waste is a relatively new concept and requires better policy support. It is associated with high cost and complexity, as we currently have a vast range of materials and products.

Investments are needed to tackle the significant shortcomings in our recycling infrastructure at various stages, including collection, segregation, and processing. There are regional differences in plastic recycling capacity and transitioning recycling to be fit for purpose has been a slow process thus far. For example, chemical recycling is at <1% of EU polymer production and only likely to rise to 1-3% in the next few years.

Both technical and social factors need to be addressed to effectively valorise plastic waste. Each polymer presents unique recycling challenges. For instance, while PET is highly recyclable, its recycling process generates fine particulate fibre waste with polyolefin contamination. Public perception and knowledge gaps also pose significant hurdles. For example, consumer preferences for colourless polymers often conflict with their demand for recycled materials, as recycled materials are frequently discoloured.

Finally, waste valorisation needs to make sense from a technical and energetics point of view. Several questions were raised: *Are the resources invested worth the value retained? Is waste valorisation feasible for all materials? How much material do we want to retain? What is the value being sought? Why are there no solutions at scale so far?* It was perceived that waste valorisation is economically challenging, and that energy inputs are often greater than the value generated. While there may be social pressures to take a CE approach to plastics, this may not always be the right approach.

Changes in Polymer Manufacturing in the Supply Chain:

Legislation, such as mandated percentage recycled content in plastics and greater inclusion of bio-based materials, is required to enable industry to shift towards waste valorisation and more circular production routes. This includes utilising the vast quantity of plastic waste (EU 53 Mt in 2019) and ensuring pyrolysis oil is going to oil facilities, and not burnt as fuel. High incentives for SAFs and biofuels (e.g. UK mandates and revenue certainty mechanisms) currently make it difficult for chemical manufacturers to compete for raw materials, so policies are needed to increase the viability of bio-based chemicals.

Bio-based production of chemicals is not yet feasible across the board. Bio-based production of naphtha, a platform chemical, is well established, with companies often using a mass balance approach. However, substituting aromatic monomers remains an unsolved problem for defossilising polymers. Production of bio-based aromatic polymers is highly emissive, and their properties fall short of traditional fossil-based materials. Bio-based terephthalic acid has a higher carbon footprint than fossil-based, while the properties of bio-based Furan dicarboxylic acid (FDCA), a leading alternative currently produced by Avantium in the Netherlands, are still not competitive e.g. it is prone to oxidation. The overall cost and carbon footprint of PET can be lowered by replacing the 30% gylcol component, with bio-based glycol. A balanced LCA for PET production, shows that the resulting 70% fossil-based PET would give the lowest overall impact.

The added resources and costs associated with circular routes need to be carefully weighed up, and innovative solutions are needed to tackle new challenges that arise. For example, pyrolysis oil for steam cracking requires costly processing to remove problematic impurities and additives. A suggestion given was introducing a grading system and mandating utilization by oil companies.

Debate on Retaining Polymer Chemicals or Depolymerisation and the Future of Chemical Recycling:

Panelists pointed out that to achieve 11MtC with 50% fossil based, requires 80% of available recycled material, assuming that 20% is lost to carbon dioxide and 30% is retained as recycled carbon. It was noted that the original carbon source, whether from fossil or advanced feedstocks, becomes less important the longer it is kept in the system.

Adhering to the waste hierarchy is key, prioritising reuse over recycling and retaining the material value for as long as possible. However, this relies on bringing consumers on board. Since behaviour change is a challenge, considering "end user effort" is key to understanding how much material can be retained in the system.

In assessing reuse of packaging, the carbon footprint depends on the number of times packaging is reused, its weight and distance travelled. For example, reusable glass milk bottles need to be used multiple times and transported over short distances to achieve a lower carbon footprint compared to conventional PET bottles. Scaled infrastructure is needed to increase the feasibility of reusable packaging. This would be enabled by consistent packaging adapted across different brands and products. However, companies may not want to streamline their packaging when this is a recognisable design feature of their product. Panelists also pointed out that reuse and streamlining may disadvantage packaging producers.

Mechanical recycling should be prioritised over processes like depolymerisation to maximize energy efficiency and resource use, particularly for polymers such as PET. Improvements in mechanical recycling and segregation infrastructure are needed, enabled by advances like AI, which is increasingly being used to sort waste, based on colour, logos, watermarks etc.

To predict the best solutions, it is necessary to understand upcoming changes in the energy system and prices along with technological advances. However, our best answers now may change in the future.

Looking Forward

The day ended by focusing on the identification and prioritisation of areas where genuine innovation is required and where partnerships between funders, academic institutions and the public and private sectors could accelerate progress and de-risk the transition to a safer and more sustainable future. Different industry and academic perspectives on challenges and future of chemical recycling, the development and analysis of sustainable processes (touching on the value of virgin polymers and changes in polymer manufacturing) and clean energy systems and working as a Research and Technology Organisation at the interface with industry and academia. Panelists emphasised that we cannot wait for the 'right time' for the 'right solution' – we must act now.

This workshop session highlighted several important challenges and opportunities in the field of sustainable materials that the community should seize on in the next 5 years.

Regulatory Science Networks –
e.g. Biobased and biodegradable materials regulatory network, Life cycle assessment regulatory science and innovation network

- Avoid unintended consequences
- Develop skills base and accreditation
- Establish Life Cycle Assessment (LCA) Network
- Focus on environmental and economic sustainability

Innovate UK has announced a further investment of £4.7 million, for 11 new networks to develop regulatory science.

Value Chain Considerations – Grantham Institute

- Consider the entire value chain, including end-of-life
- Develop digital tools for rapid measurement
- Implement vertically and horizontally integrated systems
- Explore methods to retain value in virgin materials

Innovation in Materials

- Research high-performance thermosets and depolymerization techniques
- Address challenges with dispersive materials (e.g., homecare and personal care products)
- Develop solutions for colorless products and coatings
- Consider both visible and invisible carbon in products
- Methods to produce aromatic compounds (for performance), which is challenging from bio-derived materials.

Rethinking Polymers – Roundtable Discussions Report

Biobased Materials
- Recognize limitations of biobased materials, especially for aromatic functions
- Compete with fossil-based materials on an equal basis (e.g., bio-naphtha vs. fossil naphtha)

Sustainable Carbon Goals the Sustainable Carbon Ambition Report 2050
High demand – need to retain 80% of the recycled carbon using as little energy as possible.
Aim for 4.5 million tonnes of carbon by 2050:
- 30% biomass
- 20% fossil
- 20% captured CO2
- 30% recycled carbon

Recycling and Deconstruction
- Prioritize energy-efficient recycling methods
- Develop a deconstruction hierarchy (e.g., consider rate of depolymerization)
- Ensure clean and well-sorted waste streams
- Design polymers for depolymerization
- Consider plastic additives in recycling processes

UK Initiatives
- Leverage UK's strength in polymer chemistry (design for depolymerization under conditions not exposed to in useful life).
- Anticipate publication of UK Compostables guidance in April

Authors and Acknowledgements

The workshop was led by UKRI CircularChem (Prof. Elizabeth Gibson, Sydnee O'Brien and Dr Miriam Fsadni), Royal Society of Chemistry (Prof Anju Massey-Brooker and Dr Kate Carlisle) and Innovate UK (Dr Peter Clark and Prof Sally Beken).

Rethinking Polymers Event Programme Schedule

Session 1:	Industry perspective on policy and regulation on polymers Chaired by **Duncan Lugton**, Head of Policy and Impact, Institution of Chemical Engineers
9:55 AM to 10 AM	Introduction to Session 1: **Duncan Lugton**, IChemE
10 AM to 10:15 AM	Introductory presentation by **Dr Dan Korbel,** Royal Society of Chemistry.
10:15 AM to 11 AM	Panel Discussion: **Dr Feja Lesniewska**, University of Surrey **Dr Thomas Baker,** WRAP **Dr Nima Roohpour**, Reckitt **Dr Anna Zhenova,** Green Rose Chemistry **Prof Jonathan Seville,** University of Birmingham
11 AM to 11:45 AM	Roundtable Discussion on policy impacts on the chemical (and aligned) industry

Rethinking Polymers – Roundtable Discussions Report

Session 2:	Making PLFs industry ready: Chaired by **Professor Anju Massey-Brooker** and **Dr Kate Carlisle**, Polymers in Liquid Formulations 2040 Initiative, Royal Society of Chemistry
1 PM to 1:05 PM	Introduction to session 2: **Professor Anju Massey-Brooker**, Royal Society of Chemistry
1:05 PM to 1:25 PM	**Introductory presentations:** **1.05 – 1.15 PM:** Digital Twinning to drive Industrial productivity and Net Zero ambition - **Professor Jin Xuan**, University of Surrey **1.15 – 1.25 PM:** Mass balance accounting as the key enabler for the Green Deal transformation: challenges and opportunities for adoption - **Dr Tony Heslop**, BASF
1:25 PM to 1:50 PM	Challenges and opportunities for developing Life Cycle Assessment tools for PLFs (5 mins and Q&A) - **Dr Lorraine Ferris**, Henry Royce Institute Methods and mechanistic understanding of Biodegradability of PLFs (5 mins and Q&A) - **Professor Andrew Dove**, University of Birmingham Methods & Measurements for studying degradation pathways of sustainable PLFs (5 mins and Q&A) - **Dr Harry Barraza**, National Measurement Laboratory LGC AI/Digital Twinning (Q&A) - **Professor Jin Xuan**, University of Surrey Mass Balance Chain of Custody (Q&A) - **Dr Tony Heslop**, BASF
1:50 PM to 2:25 PM	Roundtable Discussions (Topics: Biodegradability, Mass balance chain of custody, LCA, Digital twinning)
Session 3:	Identification and prioritisation of areas where genuine innovation required, chaired by **Dr Peter Clark** and **Professor Sally Beken**, Innovate UK Business Connect
2:45 PM to 2:55 PM	Opening remarks: Key Reflections from UKCPN - **Professor Sally Beken**, Fellow IOM3 & Chair of Polymer Group; Honorary Professor, Brunel University; Lead on Circular Plastics Network, Innovate UK Business Connect
2:55PM to 3:45 PM	Panel Discussion, Chaired by Sally & Peter: Big industry perspective on innovation challenges of multinational outside of PLFs, thinking about this form feedstocks and end of life perspective - **Dr Gary Walker**, Lubrizol Challenges of a chemical recycler looking to put recycled carbon (oil) back into the supply chain - **Marvine Besong**, DeepTech Recycling Experience of both academia and industry – experiences from TransFire - **Professor Matthew Unthank,** Northumbria University Experience from working as RTO with industry and academia - **Dr Pierre Martin**, CPI Research in the development and analysis of sustainable processes and clean energy systems - **Professor Rachael Rothman**, University of Sheffield
3:45 PM to 4 PM	Interactive voting on innovation priorities
4 PM to 4:10 PM	Closing remarks & next steps – **Professor Libby Gibson**

Further Resources

UKRI Interdisciplinary Centre for Circular Chemical Economy. Rethinking Polymers: Sustainable and Circular by Design. See https://www.circular-chemical.org/events/rethinking-polymers-sustainable-and-circular-by-design/; https://www.circular-chemical.org/news/rethinking-polymers-sustainable-and-circular-by-design/ (accessed 24 February 2024).

Organisation for Economic Co-operation and Development. 1992 Test No. 301: Ready Biodegradability, OECD Guidelines for the Testing of Chemicals, Section 3. See https://www.oecd.org/en/publications/test-no-301-ready-biodegradability_9789264070349-en.html (accessed 24 February 2024).

European Union. 2024 EU's Digital Product Passport: Advancing Transparency and Sustainability. See https://data.europa.eu/en/news-events/news/eus-digital-product-passport-advancing-transparency-and-sustainability (accessed 24 February 2024).

Department for Environment, Food & Rural Affairs. 2025 Consultation Outcome: Call for Evidence to Support the Near Elimination of Biodegradable Waste Disposal in Landfill from 2028. See https://www.gov.uk/government/consultations/near-elimination-of-biodegradable-waste-to-landfill/public-feedback/call-for-evidence-to-support-the-near-elimination-of-biodegradable-waste-disposal-in-landfill-from-2028 (accessed 24 February 2024).

UKRI Interdisciplinary Centre for Circular Chemical Economy. 2024 Carbon & Cash: Financing a Circular Chemical Economy. See https://www.circular-chemical.org/wp-content/uploads/2024/11/Financing-a-Circular-Chemical-Economy-Policy-White-Paper-November-2024.pdf (accessed 24 February 2024).

Innovate UK Business Connect. UK Chem 2050: Sustainable Carbon Ambition for the UK Chemicals Industry. See https://iuk-business-connect.org.uk/wp-content/uploads/2024/08/IUK-Sustainable-Carbon-Report.pdf (accessed 24 February 2024).

The Royal Society. 2024 Catalysing Change: Defossilising the Chemical Industry - Policy Briefing. See https://royalsociety.org/news-resources/projects/defossilising-chemicals/ (accessed 24 February 2024).