Fraunhofer CCPE takes a stand

AI in the plastics value chain by 2030

With the format "Fraunhofer CCPE takes a stand", we address topics that concern society, business, and science. As researchers, we want to take a stand and contribute to objectivity in controversial debates on. At the same time, we highlight where we, as institutes of the Fraunhofer Cluster of Excellence Circular Plastics Economy CCPE, can offer solutions to economic challenges.

Our positions are developed through collegial exchange and reflect the opinion-forming process within Fraunhofer CCPE. We present in-depth analyses and different views transparently in the detailed accompanying background report "Landscape Analysis and Survey: AI in the Plastics Value Chain by 2030."

Background and scope

The industrial use of plastics faces major challenges and, at the same time, new opportunities. After years of growth, the production, processing, and recycling of plastics in Germany and other European countries is currently declining compared to previous years [Plastics Europe-2025]. At the same time, regulatory requirements (e.g., in the areas of recycled content, ecodesign, and digital product passports) are increasing the pressure for greater recyclability and transparency [European Union-2024a; European Union-2024b]. The use of artificial intelligence (AI) is influencing many industries and is also affecting the plastics industry. Due to the high dynamics and low AI adoption rate, much potential in processing and recycling remains untapped. This position paper summarizes the status and potential for the use of AI in the plastics value chain until 2030 from the perspective of the Cluster.

Data basis: The position paper is based on a landscape analysis of publicly available sources as well as a survey of experts among 46 participants at Fraunhofer CCPE and project partners from the research projects "KIOptiPack" and "K^{3}ICycling" funded by the Federal Ministry of Research, Technology, and Space (BMFTR).

Goal: Compilation of specific recommendations for industry, politics, and research to promote intelligent recycling for plastics by 2030.

In focus: AI in the plastics value chain

Artificial intelligence (AI): AI encompasses data-based processes—in particular machine learning and deep learning—that recognize patterns in data, make predictions, generate their own content, support decision-making, or learn (sub)tasks and automate them in an agent-based manner. The landscape analysis and survey show that AI is already being used in the plastics industry for image processing, process control, and quality assurance.

Questions and positions

The position paper provides recommendations and a list of priorities from the application-oriented and technology-driven perspective of Fraunhofer CCPE, supplemented by perspectives from the consortium partners of the AI hubs for plastic packaging funded by the BMFTR until the end of 2025. It is primarily aimed at industry players along the plastics value chain as well as research and politics. The **question** is: "How can AI be used as a central lever in the plastics value chain by 2030 to remedy material, process, and data deficits, and what are the potentials and obstacles along the way?"

Based on our landscape analysis, AI-supported thesis formation, and a survey of 46 experts, the position paper paints a consistent picture of the role of AI in plastics value creation by 2030. The methodological approach is described in detail in the background report. The position paper delivers the following key messages:

- AI is already performing well in clearly defined applications in the plastics value chain and is seen as a key lever for increasing efficiency, quality, and recyclability by 2030.
- The bottleneck for intelligent, closed-loop circularity lies less in technical innovations than in the lack of interoperable databases, standards, governance structures, and viable business models.
- Economic efficiency, distribution of costs and benefits, liability issues, and a practicable, risk-oriented regulatory framework will determine whether AI solutions are scaled up from pilot projects to continuous industrial operation.
- AI is an important lever, but not the only one: design for recycling, robust collection and recycling infrastructure, and clear regulation remain indispensable cornerstones of the circular plastics economy.

In focus: Quotes from the experts surveyed

Data availability:
"Without a common, reliable database that is accessible to all, all further AI and digitization approaches in the plastics value chain will remain piecemeal."
"Data is often stored somewhere in an unstructured or poorly documented manner. Historically, our data storage systems have been designed to be readable by humans, not machines. New structures are needed to make data securely available for AI applications and across multiple stakeholders in the long term."

Economic efficiency:
"I believe that the most important driver for uptake is pressure from the (international) market. Without disruptive impulses, maintaining the status quo offers sufficient advantages."

Regulation:
Pro argument: "No one can seriously assess the long-term risk posed by AI at the current pace of development. Politicians should regulate strictly across the board. An unknown risk should always be classified as high when it comes to such a profound technology."
Critical perspective: "I tend to think that the legal framework could slow down the development of AI, rather than its use."

Acceptance and competencies:
"Benefits, explainability, and clear human responsibility create trust and acceptance."
"The question is whether, in the long term, we will forget our own know-how/skills through the use of AI because we rely on the new intelligence."

In focus: AI is not a solution for everything

In principle, AI are mathematical models that can solve many complex problems, but AI is not the only lever that should be considered. A comprehensive solution for optimizing the plastics cycle requires much more than mathematical models. Design for recycling, product simplification, robust collection and recycling infrastructure, and clear regulation remain indispensable cornerstones of the circular plastics economy.

Necessary steps and recommendations

The majority of respondents consider the increased use of AI solutions to be technically feasible. The experts' recommendations primarily addressed bottlenecks in:

- standardization and integration in heterogeneous corporate landscapes,
- IP conflicts and willingness to share data,
- economic and psychological factors (lack of business case and risk perception),
- coordination at the EU and global level.

Further potential lies in various organizational measures. For example, the establishment of partnerships, living labs, and joint platforms are considered necessary steps. At the same time, there is skepticism that without clear governance and business models, many parallel, competing initiatives will emerge. For this reason, many respondents see the need for alliances and industry-related research activities as a link and an important next step in cooperation between research and industry.

Several experts point to the different roles of small and large companies. For small and medium-sized enterprises (SMEs) in particular, this often means disproportionate integration, data, and compliance costs, even though they have fewer resources. Large corporations and equipment manufacturers could drive standards and data rooms from above in order to secure clear competitive advantages for themselves. Particularly in the field of waste management and recycling, some experts emphasized the need for specific support for SMEs as this is a systemically critical area. Specific support of SMEs is necessary to avoid the digital divide, to realise circular plastic streams and ensure the regulatory demanded transparency and trustworthiness of data.

AI itself has significant energy and resource demands (e.g. for training and data centres). The net effect on society and the environment is not necessarily positive. This depends on various factors and is therefore difficult to assess. Several experts highlight the need for a systematic assessment of the environmental footprint of AI-based solutions within the context of a circular economy for plastics.

Priorities until 2030: Among the priorities until 2030, however, some respondents also make it clear that although AI is a key lever for exploiting and closing data, material, and process gaps, it does not replace traditional levers such as good design, robust infrastructure, and clear regulatory guidelines.

Our priorities are:

1. Establishing and using shared data platforms on which all participants along the plastics value chain can store and exchange material, process, quality, and life-cycle data in a structured manner according to uniform, industry-specific "data language rules" (ontologies/standards) – as a basis for reliable AI applications and digital product passports.
2. Developing, testing, and scaling hybrid, explainable, and uncertainty-aware AI models in living labs and end-to-end demonstrators, from design to processing, collection, and sorting to recyclate – including robust assessments of economic efficiency and environmental impact.
3. Forming governance, business, and training models that enable data sharing, trustworthy use of AI, and the development of bridging competencies between materials/processes, data/AI, and operations in industry, research, and administration.

Fraunhofer CCPE will drive these priorities forward as a neutral, industry-oriented research partner by co-developing AI applications and model standards, carrying out demonstrator projects, and working with partners to bridge the gap between research, industry, and politics for a circular plastics economy by 2030.

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Further information on the AI hubs for plastic packaging and the BMFTR-funded research projects "KIOptiPack" and "K^{3}ICycling" can be found at: https://ki-hub-kunststoffverpackungen.de/en/

About Fraunhofer CCPE

The Fraunhofer **Cluster of Excellence Circular Plastics Economy CCPE** brings together the expertise of six Fraunhofer Institutes to develop application-oriented solutions for the circular plastics industry. With state-of-the-art facilities, in-house expertise, and an interdisciplinary team, the cluster covers a wide range of products, technologies, and services. Fraunhofer CCPE also researches and strengthens the potential of innovative AI technologies along the plastics value chain. From Fraunhofer CCPE's perspective, AI can only realize its potential for a circular plastics economy by 2030 if technical excellence is combined with a systemic perspective, open data structures, and responsible research.

Fraunhofer CCPE understands **AI as a key lever for closing material, process, and data gaps**. Priorities include interoperable data spaces, domain-specific standards, and hybrid, explainable AI models that are validated along real value chains. At the same time, the cluster acts as a neutral bridge builder between industry, research, and politics to enable trustworthy best practices, shared learning, and scalable solutions. The theses and recommendations formulated in the position paper reflect this stance. They aim at a European competitive, resource-efficient, and socially accepted use of AI in plastics value creation, in which economic, ecological, and social goals are explicitly balanced.

More about Fraunhofer CCPE:
https://www.ccpe.fraunhofer.de/en.html

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