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Overcoming System Boundaries: Closing Material Cycles in the Chemical Industry

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Abstract: BASF pioneers circular economy initiatives in the chemical industry, aiming to replace fossil-based materials with bio-based and recycled alternatives. Encouraging a positive "can do" mentality through its Circular Economy Co-funding program, the company fosters innovation and collaboration across diverse sectors. By embracing digital solutions and supporting upcoming industry ecosystems, BASF seeks to overcome barriers and create sustainable business models, committed to transforming their operations and contributing to a more sustainable future.

Keywords: Circular Economy, Sustainable Business Models, Business Model Innovation, Digital Innovation, Circular Ecosystems

Überwinden von Systemgrenzen – Schließen von Materialkreisläufen in der chemischen Industrie

Zusammenfassung: BASF ist Vorreiter bei Kreislaufinitiativen in der Chemieindustrie und strebt an, fossile Rohstoffe durch biobasierte und recycelte Alternativen zu ersetzen. Das Unternehmen fördert eine positive „Can-do"-Mentalität durch sein Circular Economy Co-Funding-Programm, das Innovation und Zusammenarbeit über verschiedene Branchen hinweg unterstützt. Durch den Einsatz digitaler Lösungen und die Förderung aufkommender Industrie-Ökosysteme will BASF bestehende Hürden überwinden und nachhaltige Geschäftsmodelle schaffen – mit dem klaren Ziel, die eigenen Geschäftsprozesse zu transformieren und zu einer nachhaltigeren Zukunft beizutragen.

Stichwörter: Kreislaufwirtschaft, Nachhaltige Geschäftsmodelle, Geschäftsmodellinnovation, Digitale Innovation, Zirkuläre Ökosysteme

BASF, headquartered in Germany, is one of the largest chemical corporations in the world. The company serves customers in almost all industries, for example automotive, construction, consumer goods, personal care as well as agriculture. In 2024, BASF processed approximately 30 million metric tons of raw materials. Simply put, a few base chemicals derived from crude oil are used to produce a large variety of products. To exchange these fossil-based raw materials with bio-based and recycled based materials remains a challenge for the whole industry. It also shows the need for greater integration of circular economy principles.

The think-tank Systemiq outlines a vision for the chemical industry emphasizing growth opportunities through the replacement of fossil-based products in their report "Planet Positive Chemicals". These opportunities lie in sourcing alternative materials currently viewed

as scrap, as well as in better organizing ecosystems to reduce costs. Finally, rethinking the design of products and services with circularity firmly embedded at their core will provide long-term competitive advantages. Nevertheless, this transformation represents one of the industry's most significant challenges. Why is this change so difficult?

To make circular economy a sustainable business case, several hurdles must be overcome. In this article we want to focus on challenges at the company level as well as system-related challenges and the role of digitalization.

Circular Business Models in the Chemical Industry

When looking at company-level challenges, we must differentiate between business models close to the company's core activities and those that are further away and require a new circular ecosystem set-up.

The circular business model that is closest to the current model outlined above involves exchanging fossil-based raw materials with e.g. bio-naphtha or biogas at the beginning of the chemical production process while continuing to use the existing infrastructure, i.e. the steam cracker. Here, focus is on sourcing costs of those alternative raw materials and the possibility to pass on these additional costs to the entire value chain. This raw material shift is the major challenge today and will continue to be so in the next decade.

Many closing-the-loop business models involve new assets as well as a whole new ecosystem of partners to work with. One example is BASF's Loopamid® project in which a solution was developed to recycle mixed textile waste with a high nylon content, transforming it into a raw material suitable for creating entirely new sustainable clothing. This represents a significant technological advancement in the textile industry. Additionally, in collaboration with Inditex, BASF developed a fully circular jacket made exclusively from a single material and designed specifically for circularity. Apart from the technical development, new partnership models were set-up and new assets needed to be deployed.

To achieve such new business models is difficult and this undertaking has been described by academia as the "innovator's dilemma," first articulated by Clayton M. Christensen. It illustrates how established and successful companies struggle to adopt disruptive technologies, which may initially be less efficient by design. In the chemical industry, existing value chains have been thoroughly optimized over several decades, particularly in the processing of chemicals within large-scale production facilities. Therefore, to set-up business models where these assets are only partially used, presents additional challenges.

Internal Co-funding Program for Circular Economy

To generally advance circular business models and help them overcome these and other hurdles, we have set-up the internal Circular Economy Co-funding program.

The program encourages employees to test and deploy circular business model concepts. This initiative not only assists in overcoming challenges but also fosters a shift in mindset towards adopting circular business models. To date, we have incubated 65 projects across all global regions and diverse markets. These projects received coaching and support from our Circular Economy Strategy Group and internal consulting specialists.

Our learnings from this program extend beyond technical aspects, encompassing challenges related to waste sourcing (both post-consumer and post-industrial), logistics (especially cross-border), and marketing strategies (including pricing and claims) as well as

digitalization topics. Other projects include efforts to enable recycling with e.g. additives for mechanical recycling, develop digital market platforms, orchestrate circular systems, and focus on service-oriented solutions as well as replacing fossil-based raw materials with bio-based feedstock. These global learnings are regularly shared through targeted community exchange. This exchange enriches our understanding of how circularity can be effectively implemented in diverse contexts.

The authors believe that setting up new ecosystems and developing digital solutions are the key to overcoming barriers in circular models. Therefore, the following paragraph focuses on these two topics.

The need for ecosystem thinking

The first point is the functioning circular ecosystem that allows scaling. One example is end-of-life vehicle recycling in Germany. Most vehicle dismantlers in Germany lack the capacity to scale up material recycling and component reuse. With over 1,000 car dismantling companies in Germany; the market remains highly fragmented. Many of these are small businesses, only capable of scrapping a low number of cars per year, with recycling efforts largely restricted to metals. Many dismantling companies lack the know-how and financial strength to establish digital interfaces to increase the degree of automation and to network digitally with material or component recyclers. An average car contains hundreds of plastic parts made of different materials, in total 150 – 200 kg. In the end, the chemical industry needs thousands of tons of used, at best well sorted plastics, which ideally are not significantly more expensive than fossil products.

BASF is actively engaged in CATENA-X, an initiative with over 100 partners which builds a data ecosystem for the automotive industry and develops standards which are the foundation to achieve scalability. Standards are being developed to address key areas such as common data-exchange formats, product passports and the calculation of product carbon footprints. These standards are a precondition to e.g. accurately calculate recycling quotas. Close collaboration in an ecosystem regarding standards triggers new market opportunities and leads to new investments needed.

Additionally, greater value can be recovered from car parts at the end of their life cycle. However, various factors need to be clarified to determine whether parts are suitable for it, e.g. how good the condition of the part in question is, how expensive is the dismantling, how high are the costs for cleaning or remanufacturing, how expensive are the costs for shipping and determining an achievable sales price. Addressing this will involve establishing an IT infrastructure that connects dismantlers, utilizing algorithms to optimize parts usage at the end of life, i.e. via a new ecosystem.

Circular requires digital solutions

The second challenge arises from the lack of digital information available in many industries on the use phase of products and materials. This means that during the production of a product, e.g. an outdoor jacket, the information on product composition of raw materials and sometimes also its recyclability is available. But once the product passes the cashier, that information is not automatically processable or even gets lost during the use phase. Thus, there is low information transparency e.g. regarding the material composition, location, ownership or the value of components at the end of the life cycle. The

lack of information is a main reason why end-of-life materials are not treated as valuable feedstock. The digital product passports as outlined in the ESPR legislation addresses this problem. A digital product passport contains information on products and materials that are digitally stored and passed on throughout the value chain until the end of the life cycle, like a label, which is found in many textiles, but containing technical information that is relevant for collection, sorting, shredding and the recycling process.

The importance of developing applicable cross industry and country standards cannot be understated. Material streams have to be collected across industries to achieve economies of scale in bundling recycling assets in hubs as we can already observe e.g. in China. This transparency and the possibility to use economies of scale would attract investments into the circular economy. As material manufacturers, we are increasingly involved in data standardization efforts to enable bundling of material streams at end-of-life. This is a prerequisite for larger-scale recycling investments into digital infrastructure for collection and automized sorting as well as pretreatment processes. These processes are required to transform end-of-life materials into more homogenous feedstocks which are easier to recycle. At the moment, fossil resources are still less expensive compared to bio-based or, in many cases, recyclate-based resources.

To make this switch feasible, the whole value chain needs to bear the (initially) higher investment costs of renewable or recycled-based raw materials. Here, legislation encouraging the demand for circular products can play a role in facilitating the needed investments. We believe that focused capital expenditures into new ecosystems and digital solutions will eventually lower the cost structures and thus enable viable circular business models for many players. A good basis for creating these new eco-systems are close cooperation models that are pre-competitive. They can be supported by institutes such as Fraunhofer or international bodies such as the World Economy Forum.

In conclusion, BASF is very committed to addressing the barriers of circular business models and transforming the current landscape of the chemical industry. By leveraging digital technologies, optimizing material flows and fostering industry partnerships, BASF aims to catalyse meaningful change and seize the opportunities presented by the circular economy.

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