

**TAKING THE EUROPEAN
CHEMICAL INDUSTRY
INTO THE
CIRCULAR
ECONOMY**

EXECUTIVE SUMMARY

Sustainability has become a vital part of many business strategies across industries, and that has prompted growing interest in the circular economy—including among European chemical companies. The advent of the circular economy is likely to lead to significant changes for the industry, along with fundamental challenges. But it could present a major opportunity for the European chemical industry, and for Europe overall.

These are some of the findings of a recent Accenture study exploring the potential of the circular economy for the European chemical industry. The report looks at how the industry might shift to that type of economy, what it will take to get there, and what it will mean for chemical companies. The report takes a holistic view that goes beyond individual factors and issues—such as CO₂ emissions, plastics recycling, bio-based chemicals or landfill policy—in order to create an integrated picture of the industry in a circular economy.

Indeed, a holistic view is fundamental to understanding the circular economy, which is not simply focused on using less. Instead, it aims to keep products, components and materials at their highest utility and value at all times. It is restorative and regenerative, and ultimately does reduce resource consumption. But it is also a classic economy in the sense that all activities are aimed at generating an economic benefit. Thus, it creates incentives for market participants to contribute to a more sustainable approach to natural resources.

In essence, the circular economy seeks to replace today's linear, "take-make-dispose" approach to resources—where many materials are made into products, the products are used, and then the materials are thrown out. With the circular economy, the materials are constantly cycled back through the value chain for re-use, resulting in less energy and resource consumption.

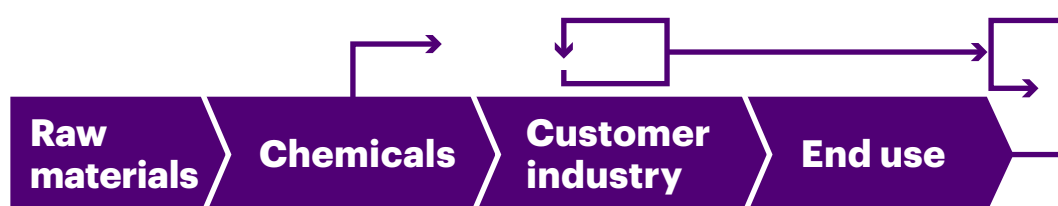
The circular economy keeps products at highest utility and value.

In some industries, elements of the circular economy are already at work. In Europe, for example, 73 percent of all glass bottles are now collected and recycled rather than thrown away.¹ And scrap steel makes up 50 percent of the ingredients used in new steel products.² This has helped to increase competitiveness in these industries by decreasing their dependence on virgin raw materials, such as iron ore, and by providing a more competitive raw material source. It is estimated that the steel industry saves about 20 to 25 percent of production cost from using scrap steel accounting for both raw material cost advantage and energy savings. A key difference, however, between glass and steel and chemical products, is that the production of chemical products requires modifications of molecular bonds. This modification inherently changes the nature of the product itself, and is therefore more challenging and energy intensive to pursue.

To understand the impact that the circular economy could have on the European chemical industry, it is useful to look at the issue from two perspectives: circulating molecules and enabling the circular economy in downstream industries. (See Figure 1)

Figure 1: Circularity in chemicals has two aspects:

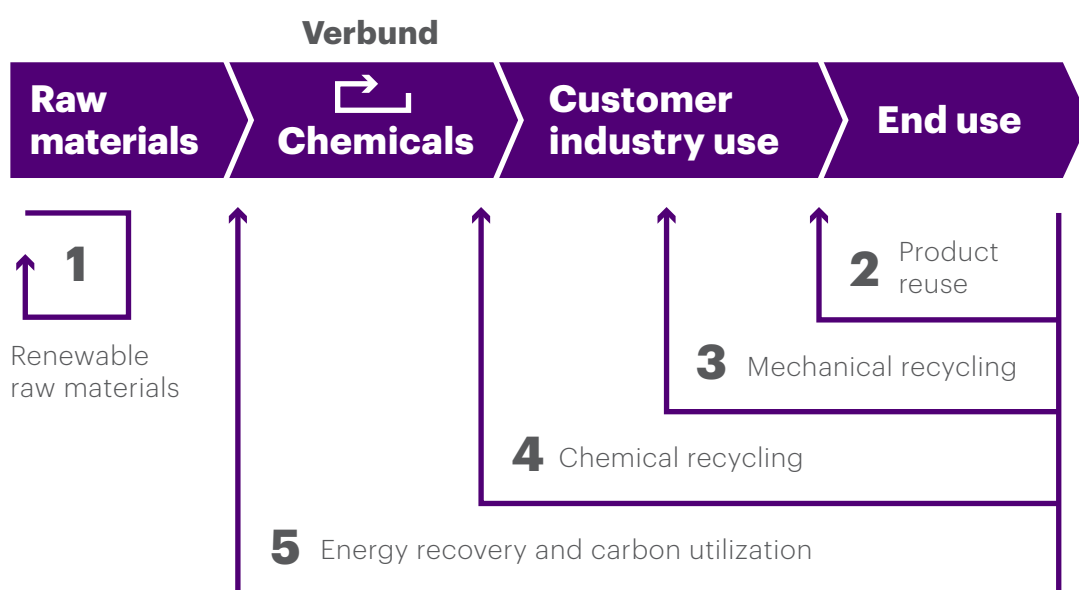
Enabling circularity



Enabling maximum utility in end usage

(e.g., higher durability of goods, making products suitable for sharing and increasing energy efficiency)

Circulating molecules



Maximizing utility of existing molecules

(e.g., reusing/recycling molecules such as through the reuse of PET bottles)

Circulating molecules: tapping into existing materials

As the term suggests, circulating molecules means re-using and recycling existing molecules that are tied up in end-consumer products that have reached the end of their lives. Accenture believes that up to 60 percent of the molecules provided by the European chemical industry to customer industries and end-users can be re-circulated if utilization of all five loops is maximized. However, this view comes with a caveat: the study was built on the assumption of abundant and cheap energy which would come from renewable sources. In the end, it is an economic trade-off between energy and the reuse of molecules. It was also assumed that the required funds for transformation would be available in the industry. These assumptions are by no means a given, and the practical reality may fall short of the 60 percent number. Nevertheless, the study demonstrates that the circular economy holds great potential for the industry.

How would the circulation of molecules be accomplished? There are five fundamental molecule-circulating loops in the chemical industry.

Each of the five loops has its own requirements and each could have a significant impact on the consumption of carbon-based raw materials.

- **Substituting raw materials.** The industry could substitute some portion of fossil feedstocks with renewable feedstocks such as biomass material (e.g., bioethanol, lactic acid, bio C_2/C_4). Re-thinking the raw materials loop would require investment in new feedstock infrastructure and conversion assets. In any case, this approach has some limitations. Replacing all feedstocks and supplying the energy needed by the industry with biomass, due to the low energy

intensity of biomass compared to fossil resources, would require the full harvest of material from more than 238,000 km² of land—an area larger than Romania and representing as much as 14 percent of the total area utilized for agriculture in the European Union today.³ So the raw-materials loop cannot be, in and of itself, a complete answer.

- **Increased re-use of end-user products.** The industry could focus on developing full suites of new products and solutions that can essentially be re-used “as is,” such as durable PET bottles. To do so, the industry might consider establishing “design to reuse” partnerships involving suppliers, original equipment manufacturers (OEMs), and companies that have close relationships with end-customers.
- **Mechanical recycling.** This involves re-using existing materials without modifying their chemical bonds. In essence, end-use materials could be collected, processed and reinserted into the upstream value chain for use in similar or downgraded applications. The recycling of thermoplastics and the extraction of phosphorus from sludge are two examples. For this loop, chemical companies would need to focus on research, development, and new product design to use mechanically recycled molecules; on developing reverse logistics capabilities; and on establishing processing partnerships.
- **Chemical recycling.** When molecules cannot be re-used in their intact structure, chemical companies could modify the material’s molecular bonds to recover hydrocarbons. This would involve breaking up long-chain hydrocarbons into precursors via processes such as catalytic cracking or plasma gasification. For this loop, the industry would need to invest in further research and development in cracking and gasification processes, as well as invest in required large scale assets.
- **Energy recovery and carbon utilization.** This involves recovering the energy contained in molecules by oxidizing hydrocarbons to CO₂, capturing it and then building new chemical feedstocks via a catalytic reaction. However, the process needed to do this is complicated. It would require new assets for creating dense CO₂ sources and for the re-synthesizing of carbon into hydrocarbons. This requires the establishment of hydrogen supply at scale. As a result, this is probably the most difficult of all loops to master.

None of these loops is a “silver-bullet” solution. Chemical companies will probably need to draw on a mix of approaches, and their options may evolve over time. While infrastructure for the end-user re-use and mechanical-recycling loops is already in place to some extent, there is still room for further expansion through the use of new technologies. In addition, the technologies and processes for the chemical recycling and carbon utilization loops are still far from mature, but development is taking place on those fronts.

The increased use of molecule-circulating loops could provide a range of benefits.

For example, a greater emphasis on product re-use and mechanical recycling would require new products and solutions intentionally designed for re-use. This would represent a massive development and growth opportunity for the industry.

These loops would also reduce the industry’s dependence on naphtha and gas-based feedstocks, with their volatile pricing. The European chemical industry could reduce the consumption of virgin fossil feedstock for conversion into chemical products, thereby limiting the amount of new carbon atoms being extracted from the earth and introduced into the atmosphere, and at the same time create a new source for European competitiveness versus raw material rich regions.

It is a clear challenge that industrial-scale chemical recycling and carbon utilization technology is not readily available. Companies would have to make significant investments in creating and operating new circular economy processes. (See Figure 2) For example, Accenture believes that about 19 million tons (Mt) of material a year could be processed through the mechanical-recycling loop in Europe, but doing so would require an infrastructure investment of as much as EUR 10 to 20 billion. For a chemical-recycling loop that could handle 8 Mt a year, that figure could be up to EUR 30 to 80 billion.

Figure 2: Circulation volume potential, investment and energy needs by molecule loop

Molecule loop	Volume (in Mt per annum)	Chemical assets investment needed (in EUR Bn)	Energy need (in Mtoe per annum)
1. Renewable raw materials	12	20-40	Insignificant
2. Product reuse	17	n/a	n/a
3. Mechanical recycling	19	10-20	12
4. Chemical recycling	8	30-80	3
5. Carbon utilization	10	100-140	29
Total	66	160-280	44

The circulation of molecules to the extent described would require large amounts of carbon-neutral energy. Accenture calculates that fueling the loops would need 44 Mtoe of additional energy. However, adopting those practices would also lead to reduced energy usage for conventional chemicals production as we know it today, leaving a net requirement of 21 Mtoe of additional energy. For illustration, that amount of energy corresponds to 19,000 standard offshore wind turbines.

Finally, the extensive re-use of molecules would mean smaller markets for fossil-based feedstock and basic chemicals. For example, if it eventually becomes possible to fully circulate thermoplastics, then there would be a substantially reduced need to produce monomers and polymers, rendering the associated business models and assets redundant. That reduced production would be a contributing factor in the industry-wide energy savings discussed earlier.

Enabling Europe's larger circular economy

In spite of the reduced demand for some products that would result from the increased circulation of molecules, overall demand for chemical products is likely to grow—driven by the need for products that enable circularity downstream in the value chain.

The chemical industry is a supplier to virtually every other industry. As a result, it is in a position to enable circular-economy models for its downstream customers. The potential upside in terms of energy savings is tremendous. The chemical industry itself accounts for only approximately 5 percent of Europe's energy consumption, but with its extended impact across industries, chemicals could help reduce overall European energy consumption by up to 37 percent. (See Figure 3)

26% **Growth** **potential**

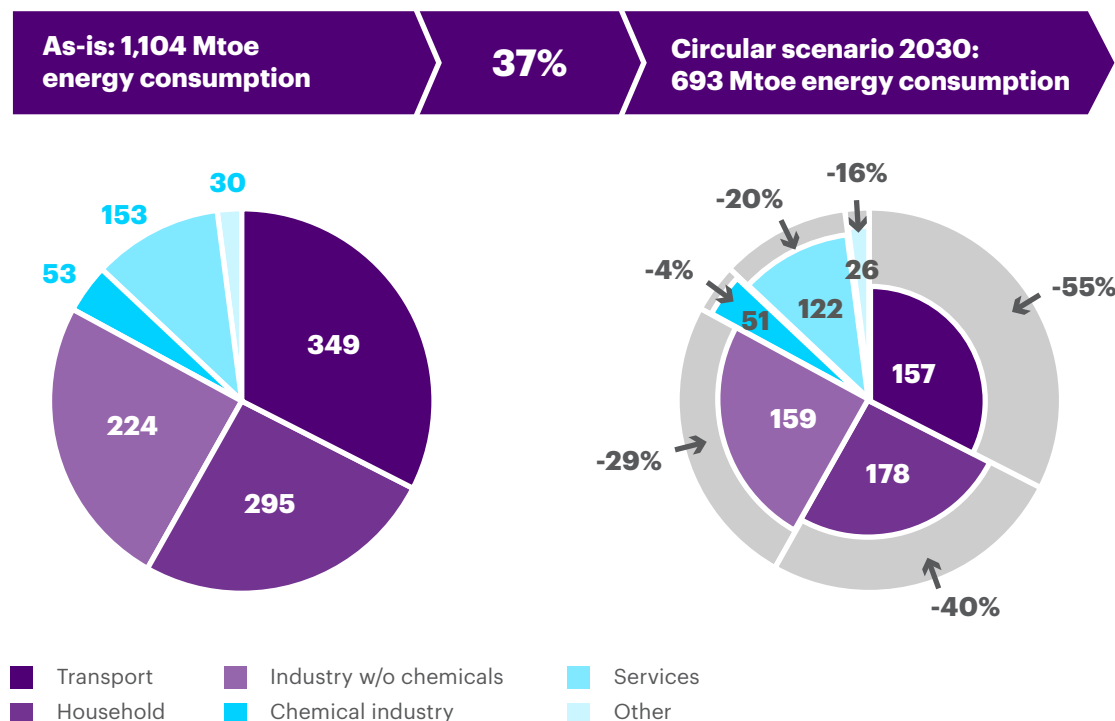
for chemical
products

Take, for example, the two most energy-consuming sectors that together account for more than 50 percent of Europe's total energy demand—transportation and housing. In the transportation area, chemical products can help reduce emissions; increase efficiency; enhance recyclability and reusability;

and prolong use cycles by contributing to lightweight cars, e-mobility and more-durable cars with longer average usage. Accenture calculates that chemical products could be instrumental in helping reduce transportation-industry energy usage from 349 Mtoe to 157 Mtoe by 2030.

Figure 3: Approximately 425 Mtoe of EU energy consumption could be reduced in a fully formed circular scenario

Energy consumption in a 2030 circularity scenario (in Mtoe)



In housing, chemical companies can make a substantial contribution to achieving the passive house energy standard by providing products such as high-performance and more durable insulation materials for walls, roofs and pipes; high-performance sealants for buildings; and high-performance window materials, such as plastic frames, glazing and surface films. Accenture projects that such products could reduce the sector's energy usage from 295 Mtoe to 178 Mtoe by 2030.

As downstream industries gradually increase adoption of the circular economy—driven by supporting regulation and growing consumer awareness—there should be a shift in demand patterns.

The cross-sector enablement of reduced energy consumption could result in tremendous growth in demand for chemical products. Accenture estimates this growth potential to be as high as 26 percent in terms of volume (or 88 Mt across basic chemicals, intermediates and chemicals for customers).

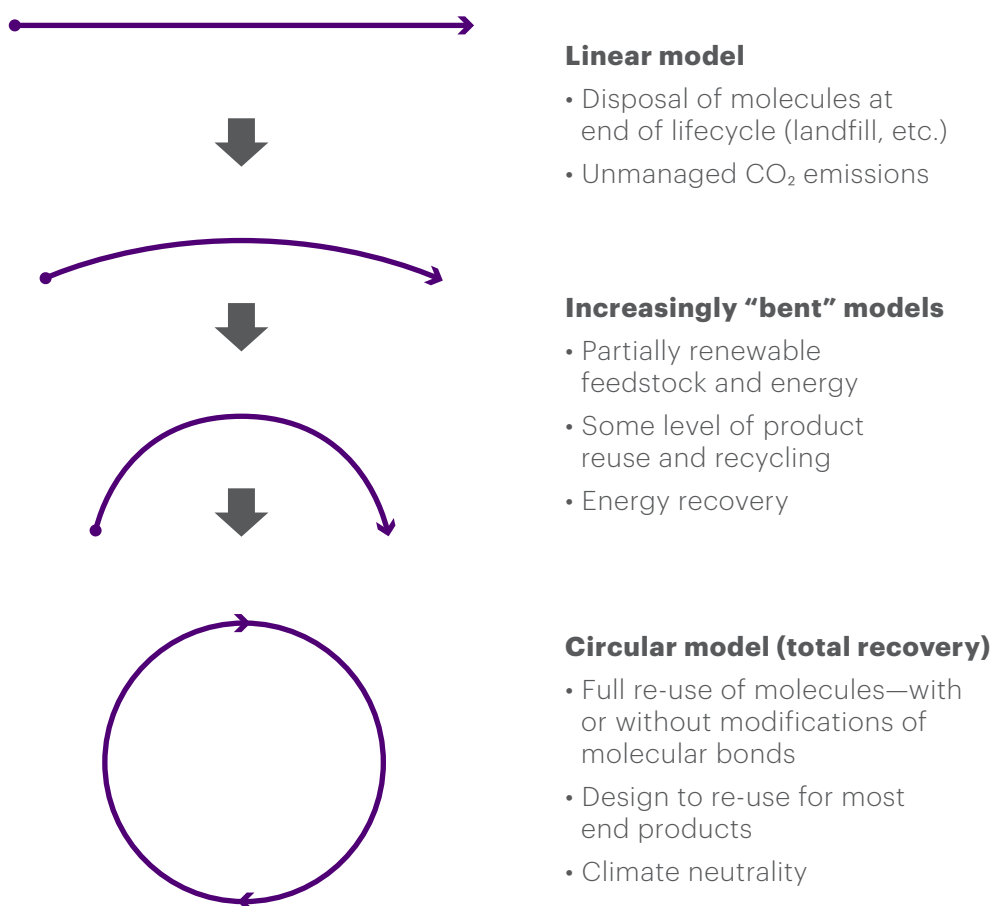
Due to the diversity of chemical products, the shifts in demand will be highly application-specific. For example, in the auto industry, the trends toward smaller vehicles and car-sharing are likely to reduce demand for standard polymers, dyes and coatings. But the greater focus on recyclability and durability is likely to increase demand for engineering polymers and specialty chemicals.

Each chemical company will need to assess the potential impact of demand change on its own business. But in general, as downstream industries provide shifting demand, there will be a move from volume to value, with growth in specialty and high-performance products.

The path forward

Moving into a circular economy will not happen overnight—the transformation will take time. Assuming that 20 percent of the European chemical industry’s capital spending will be channeled into circular-economy projects, it would take 35 to 60 years to build the chemical circulating loops described. Chemical companies can take a gradual, incremental approach. In a sense, they can “bend” the linear take-make-dispose model, working on the two ends—raw materials and increased recyclability of end products—and continue moving forward until they have created a circular model. (See Figure 4)

Figure 4: A circular economy helps enable ideal resource recovery



As European chemical companies move to the circular economy, they should consider a portfolio of integrated initiatives and plan for a transformation encompassing the entire value chain:

- Understand how the circular economy creates growth potential for their portfolios and shift capital and operating expenses accordingly.
- Prepare to shift focus from volume to value.
- Explore opportunities to benefit from new business models in areas such as chemical leasing and the management of molecule-circulating loops (e.g., infrastructure for reverse logistics).
- Increase resilience through partnering with OEMs and deeper integration with customer value chains—comparable to what can be observed in the steel industry where some players have been migrating from steel milling to downstream applications.
- Decrease dependence on oil and gas.

Today, markets and policymakers are increasingly interested in making these changes—in moving away from the traditional high-consumption model to one that is more regenerative and that maximizes the utility of resources all along their life cycles.

This study should encourage society and the industry to explore how to set the right frameworks to enable circularity in downstream uses; provide resources to close technology and innovation gaps; provide abundant, globally cost-competitive energy; and manage the transition in terms of assets, infrastructure, and work forces.

References

¹ FEVE – The European Container Glass Federation, 2016

² EUROFER – The European Steel Association, 2016

³ The calculations are based on the following assumptions: 1.1 kg oil equivalent is equal to 41.9 megajoules (MJ); the average calorific value of biomass is 17 MJ/kg; and 12 tons of biomass can be harvested per hectare per year.

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