Growth, Competitiveness, and Resilience

Circular Economy Opportunities for German Industry

May 2026

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Germany's international competitiveness is under considerable pressure in light of global supply uncertainties and declining development in key economic sectors. With more than 1.4 billion tons annually, Germany is the EU economy with the largest material input and is the world's third-largest importer of raw materials, not least due to its role as an export-oriented industrial nation. At the same time, Germany is over 99% dependent on imports from abroad in critical sectors—for key materials for technologies of the future, such as lithium, nickel, and rare earths. Despite a good situation in waste management and established repair services in many segments, value creation in German industry is still predominantly linear. While a stable supply of primary materials remains essential, Germany faces the task of securing its industrial competitiveness in international markets over the long term, fostering resilience to global risks and, at the same time, achieving climate policy goals.

This study shows for the first time the macro-economic potential that a consistent circular economy can unlock to strengthen industry—even with limited political intervention and largely based on already viable business models. Additional growth in gross value added, strengthening of resilience and security of supply for resources, and positive ecological effects are the result of the approaches considered. To this end, five key segments of German industry were examined jointly by BDI, BCG, and 13 participating companies and associations. They account for 62% of national value creation: mobility, mechanical engineering, construction, energy, and textiles. In terms of a deliberately implementation-oriented development pathway, circular business models are examined that are either already economically viable today or can become so by 2045 under stable market conditions—without requiring far-reaching government intervention or major structural changes in industry or consumer preferences.

The circular economy holds potential for value creation along the entire product life cycle

The circular economy along the value creation cycle

Source: BCG analysis

The gross value added of the circular economy could more than double from today's €60 billion to up to €125 billion in 2045—representing a growth opportunity, especially in light of the economic stagnation of recent years. The additional potential identified particularly results from *reuse*, *refurbishment*, *remanufacturing,* and *recycling*. The majority of the economic effect falls to the segments of mechanical engineering, construction, and mobility. The identified circularity levers will generate €700 billion to €880 billion, cumulatively, of gross value added by 2045. In addition, systematically expanding the circular economy will create further positive macroeconomic effects; for example, this could achieve a total savings of approximately €38 billion in the energy transition by 2045. At the individual company level, the circular economy opens up additional economic advantages; for instance, by monetizing *end-of-life* flows. Margin increases are also possible through *remanufacturing* and *refurbishment*, depending on the application and existing cost structure—in mechanical engineering, for example, with margins more than 5 percentage points higher than in classic new production. In addition, new customer segments can be tapped in circular business models.

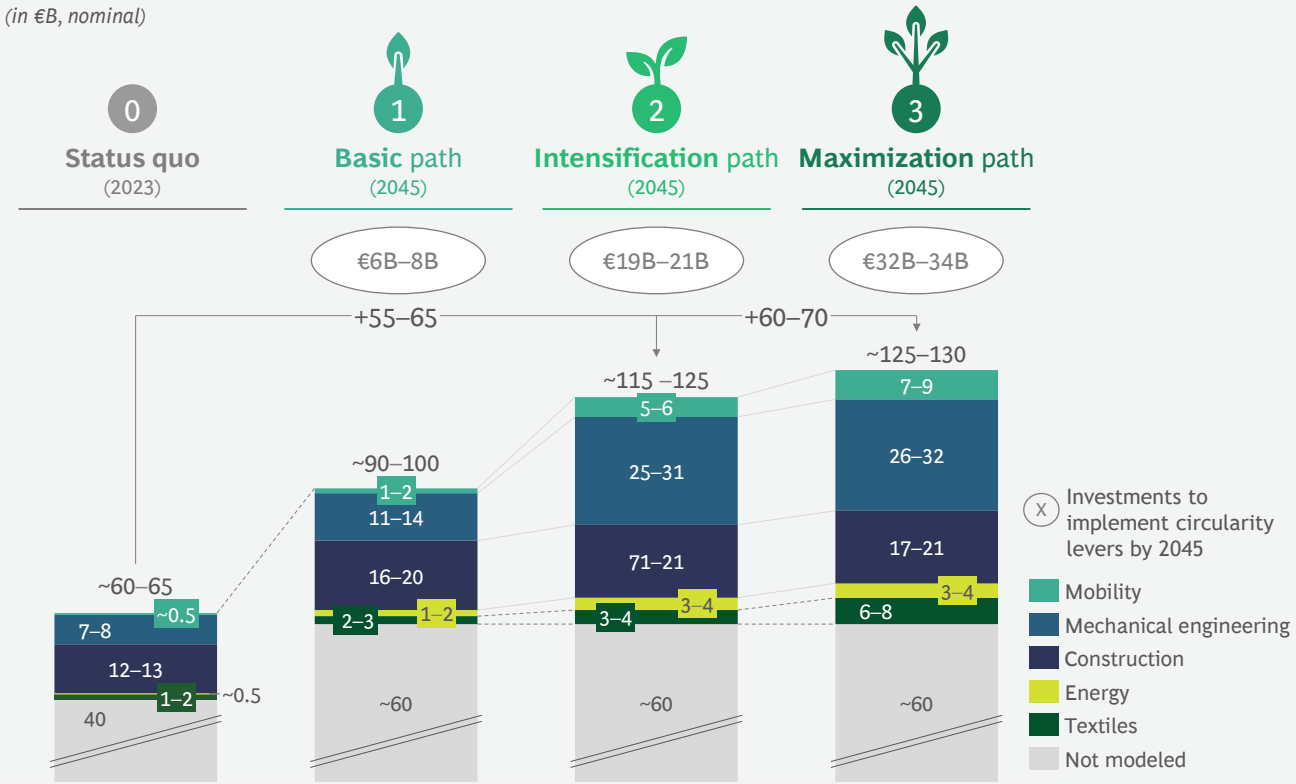
The circular economy can also strengthen resilience and security of supply at the resource level; as an example, by 2045 the import shares of rare earths and strategic battery materials could be reduced by 20% and 10%, respectively (already adjusted for the increased demand in 2045). Around 60,000 tons of annual imports of lithium, nickel, manganese, cobalt, silver, and rare earths—needed primarily in the mobility, mechanical engineering, and energy segments—could be replaced by processing in Germany. Furthermore, for industrial companies, a reduced dependence on imports and the associated geopolitical supply risks can not only reduce costs in the short term but also create structural advantages—for example, through greater planning certainty and more stable processes.

In addition, the ecological effects of the circular economy are sizable: The identified levers—which simultaneously have a positive impact on GDP—enable an additional emissions decrease of approximately 11 million tons of CO_2e in production and end-of-life phases and along global value chains. In the segments considered, the effects are multifaceted: In the mobility segment alone, the circular economy could reduce emissions of about

German in-scope industries with up to €125B in GVA potential by 2045 in the intensification path

Growth of gross value added in the development paths by segment through 2045

(in €B, nominal)



4 million tons of CO_2e in the upstream and downstream value creation steps compared to 2023. In the textile segment, the incineration shares could be reduced by 9 percentage points by establishing closed loops in Europe. In the construction segment, it would be possible to create additional living space in a material-efficient way and reduce the average use of material per apartment by 2% by 2045. In addition, the circular economy in the five segments considered could enable an annual recyclate availability of up to 83 million tons. At the same time, it offers companies the opportunity to increase material efficiency in production and support in reaching decarbonization targets.

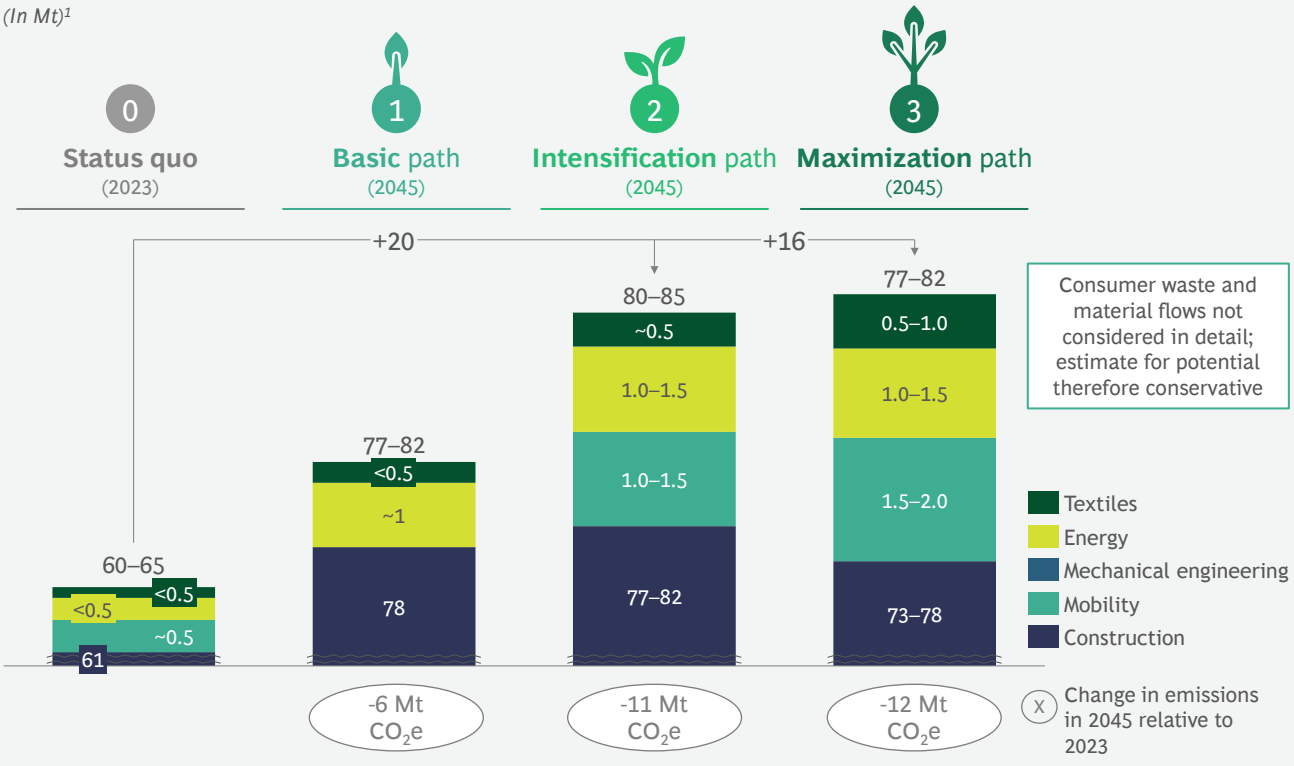
Germany processes more than 1.4 billion tons of materials from Germany and abroad every year and thus remains the EU economy with the largest material use by volume. Around 14% of materials used in industry are secondary—recyclates are scarce, material flows largely linear. This results in a growing dependence on imports, cost risks, and missed value creation domestically. Despite a dense regulatory landscape, there is a lack of a holistic approach that integrates circularity into the German economy.

The report focuses on five selected end-product industries: the mobility sector (cars, rail, batteries, excluding aircraft, and other vehicles), mechanical engineering, construction, the energy sector, and the textile sector. They account for 90% of the recorded and allocated material demand of the German economy (610 million tons).

In addition to gross value added, the circular economy provides recycled materials while reducing CO_2 emissions by up to 11M tons

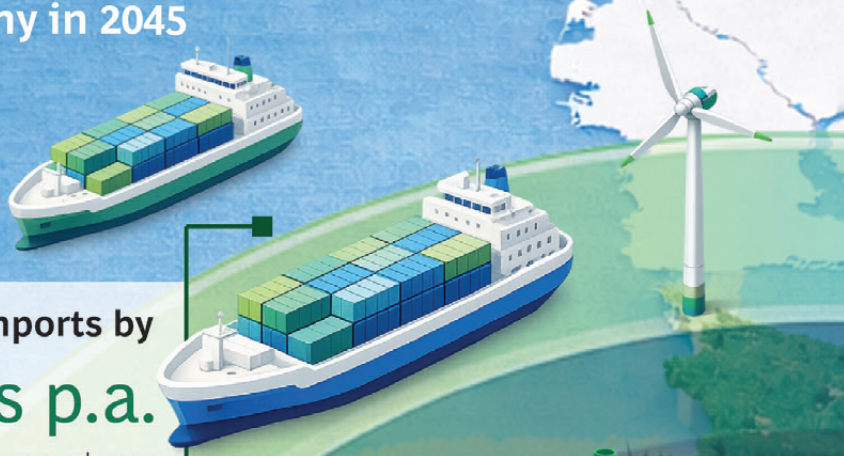
Recycled material availability on the pathways by segment through 2045

(In Mt)[1]



1. No proportional depiction of the infrastructure segment for greater visibility of the other segments

OUTLOOK: A Circular Germany in 2045



Reduction in critical imports by

60,000 tons p.a.

of lithium, nickel, manganese, cobalt, silver, and rare earths through processing in Germany

20–40% of raw material imports replaceable

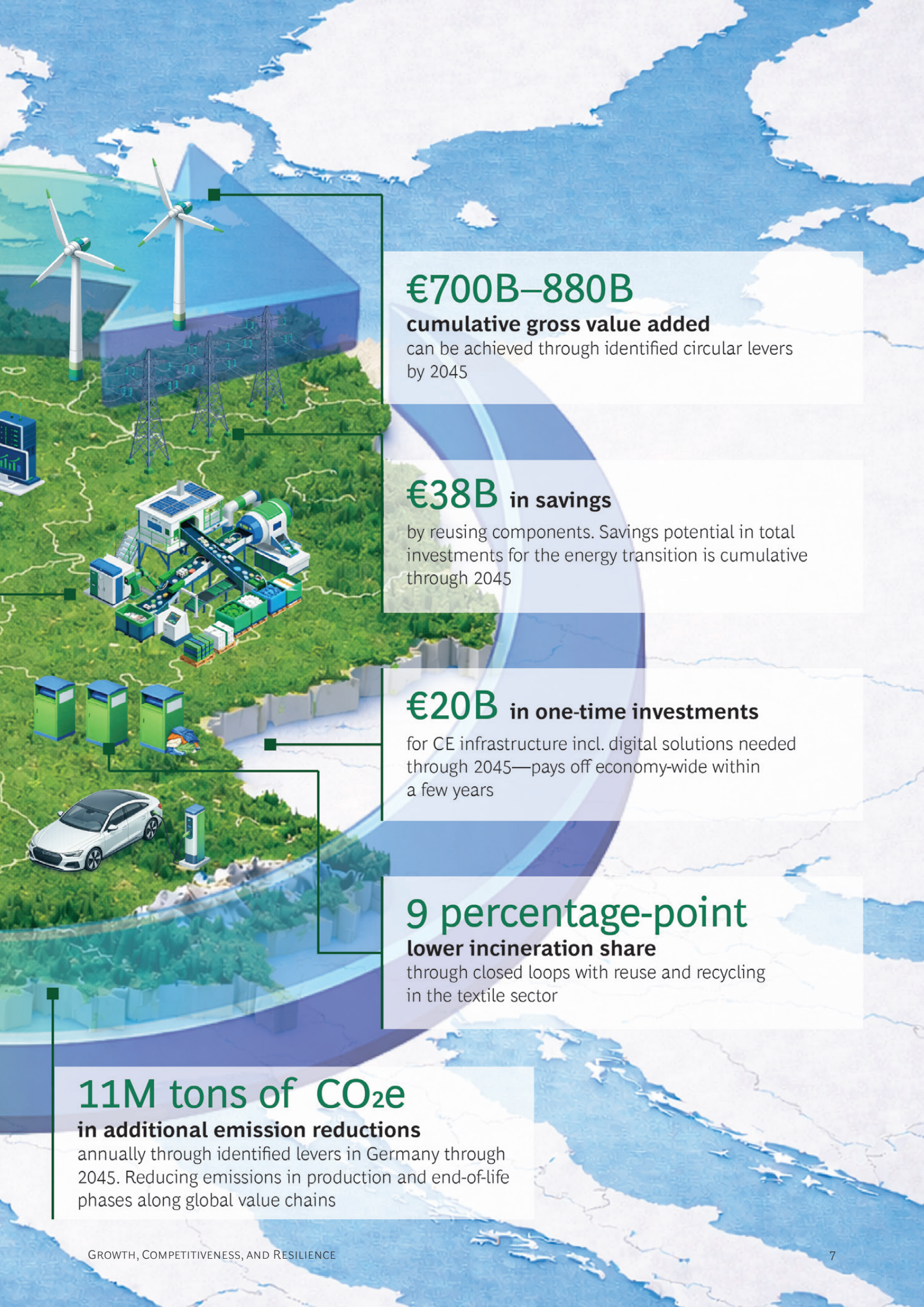
through recycling and reuse by 2045. Import dependence declines: rare earths by up to 20%, battery materials by up to 10%

Over 5% higher margins in mechanical engineering

with remanufacturing and refurbishment business models depending on application and cost structure

>€150B global market potential in 2045

for recycling technologies and software for the circular economy, which will drive the circular economy in other industries and markets



€700B–880B

cumulative gross value added

can be achieved through identified circular levers by 2045

€38B in savings

by reusing components. Savings potential in total investments for the energy transition is cumulative through 2045

€20B in one-time investments

for CE infrastructure incl. digital solutions needed through 2045—pays off economy-wide within a few years

9 percentage-point

lower incineration share

through closed loops with reuse and recycling in the textile sector

11M tons of CO_2e

in additional emission reductions

annually through identified levers in Germany through 2045. Reducing emissions in production and end-of-life phases along global value chains

Mobility: Key Industry in a Material-Intensive and Dynamic Transformation Environment

As a result of the transition from internal combustion engines to electromobility, the German automotive industry is undergoing the most profound transformation in its history. As a key material-intensive industry, it faces a dual challenge: growing dependence on raw materials and intensifying global competition. Electrification exacerbates existing supply risks. Germany's dependence on imports for strategic battery materials is in fact close to 100%. At the same time, non-European competitors have secured substantial market shares in battery cell production and electric vehicles at an early stage and are increasingly entering the European market. Raw material security and industrial value creation are thus becoming a core strategic issue for the country.

Central elements of the circular economy are already established in the automotive industry, in particular the well-developed repair and spare parts structures. However, significant potential remains untapped: Around 25% of deregistered vehicles leave the domestic cycle through exports to non-EU countries, meaning valuable materials and components are no longer available for *remanufacturing* or *recycling*. Regulatory requirements are placing a greater focus on the circular economy, but the lack of market oversight and insufficient return rates are hampering scaling.

The largest circularity levers are in component *remanufacturing* and high-quality *recycling*—especially for batteries. On the intensification path, these circularity levers could generate up to €4.8 billion in additional annual gross value added by 2045 and unlock around 1.1 million tons of material effects (direct savings and primary replacement through the availability of recycled materials). Consistent battery recycling alone could reduce import dependence for central battery materials by 10–15%. This presupposes a larger proportion of end-of-life vehicles in Germany remaining available for cycle processes, while at the same time consistently expanding processing and recycling capacities.

Mechanical Engineering: A Key Segment with Great Growth Opportunities

Mechanical engineering is under considerable pressure to innovate and lower costs, while being exposed to an increasing dependence on raw materials. At the same time, the sector plays a key role in major transformational issues—in the context of digitalization and automation as well as in circular economy and industrial decarbonization. The dependence on critical raw materials such as copper (for electric powertrains and cabling) or rare earths (for permanent magnets) illustrates the strategic relevance of circular approaches. Although some companies have already established successful business models in *remanufacturing, refurbishment*, or the recovery of critical materials, these have yet to achieve broad industrial adoption. Related activities exhibit a low level of maturity: In almost all segments, the sales share of *remanufacturing* is currently below 5%. Circular business models remain limited in scope overall. Only 13% of companies have implemented specific measures to recover rare or strategically relevant materials.

Three circularity levers for mechanical engineering form a coherent system: Firstly, *remanufacturing* and *refurbishment* enable companies in the mechanical and plant engineering sector to strengthen their cost position, develop new market segments, and increase margins by more than 5 percentage points, all while reducing their dependence on raw materials. Secondly, the increased targeting of growing markets for equipment—such as recycling technology—as well as software solutions in the context of the circular economy opens up additional growth potential. These markets will reach a volume of more than €150 billion worldwide by 2045 and will also make a significant contribution to enabling circular value creation in other industrial segments. By consistently applying these circularity levers, mechanical engineering could boost Germany's annual gross value added by more than €20 billion by 2045.

The existing barriers lie less in technological possibilities than in corporate priorities. In addition, there is a challenging regulatory environment for recyclers, which indirectly also affects technology manufacturers and can inhibit investment in circular business models.

Construction: Key Circularity Levers to Improve Material Efficiency and Preserve Material Value

Investment-related growth drivers and existing circular structures are shaping the segment profoundly. The special fund for infrastructure and climate neutrality further increases the significance of resource-efficient construction and material concepts and offers the opportunity to anchor existing circular value creation approaches in the long term. Due to its high absolute material demand, construction is an essential part of Germany's raw material base. With around 50% of the total material demand by mass—primarily soil and aggregates—the largest proportion of national material use is attributable to construction activities. Overall, the recovery rate is currently 90%. Nevertheless, the construction segment remains a central focus of the circular economy due to its extensive use of materials, the considerable amount of waste, and the emission-intensive manufacturing of key build-ing materials.

Against this backdrop, two circularity levers were identified that aim at resource efficiency by retrofitting as well as at expanding the recycling of building materials. The average use of materials per apartment created could be reduced by 2% by means of circularity levers, because efficiently retrofitting existing buildings could create 11,000 additional apartments per year by 2045—with only 1.3 million tons of additional material required. Higher *recycling* rates (adjustment of the general conditions per material fraction) for aluminum and steel and increased use of concrete waste (crushed sand) in cement production, gross value added could increase by up to €2.8 billion and make up to 79 million tons of recycled material available by 2045—which also results in additional CO_2 savings.

However, structural adjustments are required to implement these levers. In particular, consistent and improved sorting of construction waste is needed directly at the place of origin. At the same time, progress is hampered by regulatory barriers and existing trade-offs. In the retrofitting segment, many existing buildings are neither modular nor constructed in such a way that they can be comprehensively modernized.

Energy: Circularity Levers Make the Energy Transition Cheaper and More Resilient

The energy sector is in a historic restructuring phase. Building a climate-neutral energy system will require investments of more than €1 trillion over the next two decades, with considerable pressure to ensure competitive power prices at the same time. As the energy transition progresses, the sector's environmental impact is also shifting: While direct greenhouse gas emissions from fossil fuel combustion are declining, the material intensity of energy generation is increasing markedly. The expansion of renewable energy sources is accompanied by a rising demand for indirectly emission-intensive and somewhat scarce raw materials, creating new resource-related challenges. Conversely, demolishing old renewable energy plants creates new material flows that could, in the future, meet at least a part of this material demand.

In the energy sector, three circularity levers with material potential stand out: First, use plants and components longer, especially in grid and wind power plants, in order to reduce the need for new material. Second, reduce demand by utilizing electric vehicle batteries; for example, through bidirectional charging and *second-life* applications. Third, increase *recycling* rates, particularly for wind turbines, photovoltaic modules, and batteries. Especially reusing components and integrating bidirectional charging solutions can reduce the investment required on the intensification path—by around €38 billion. At the same time, all three levers will strengthen domestic value creation by more than €3 billion annually by 2045.

There are obstacles to implementation, however, especially on the demand side. Remuneration mechanisms and incentive systems must make circular solutions more economically attractive. In addition, further technological advancements and the expansion of corresponding capacities are necessary, especially in the recycling sector, in order to fully leverage the identified potential.

Textiles: Circularity Levers Enable Extensive Value Creation to Be Shifted to Germany

The textile segment is under considerable transformation pressure in view of increasing volumes of waste and stricter regulatory requirements. The global amount of textile waste has been steadily rising for years and is largely influenced by postconsumer clothing textiles. At the same time, stricter European standards and the introduction of extended producer responsibility are increasing pressure to adapt across the entire value chain. Today, the industrial value added of the German textile industry is mainly realized abroad, especially in the high-volume clothing segments. Despite a comparatively high collection rate, textile recycling remains organized linearly in large part: Significant quantities leave the cycle and are lost due to export or incineration. As a result, both material value and domestic value creation potential remain untapped.

Three levers can increase the circular value added in the segment by €2.2 billion to €5.4 billion by 2045 compared to 2023: *Reuse* enables material preservation at the highest quality level and can generate substantial new value added in Germany. In addition, fiber-to-fiber *recycling* allows high-quality material cycles to be established by substituting primary materials with recycled materials. For nonspinnable fibers, textile recycling offers additional material recovery options and provides alternatives to energy recovery, especially for challenging residual fractions. Reduced material flow losses and optimized recycling routes will allow a reduction in the proportion incinerated by 9 to 19 percentage points by 2045.

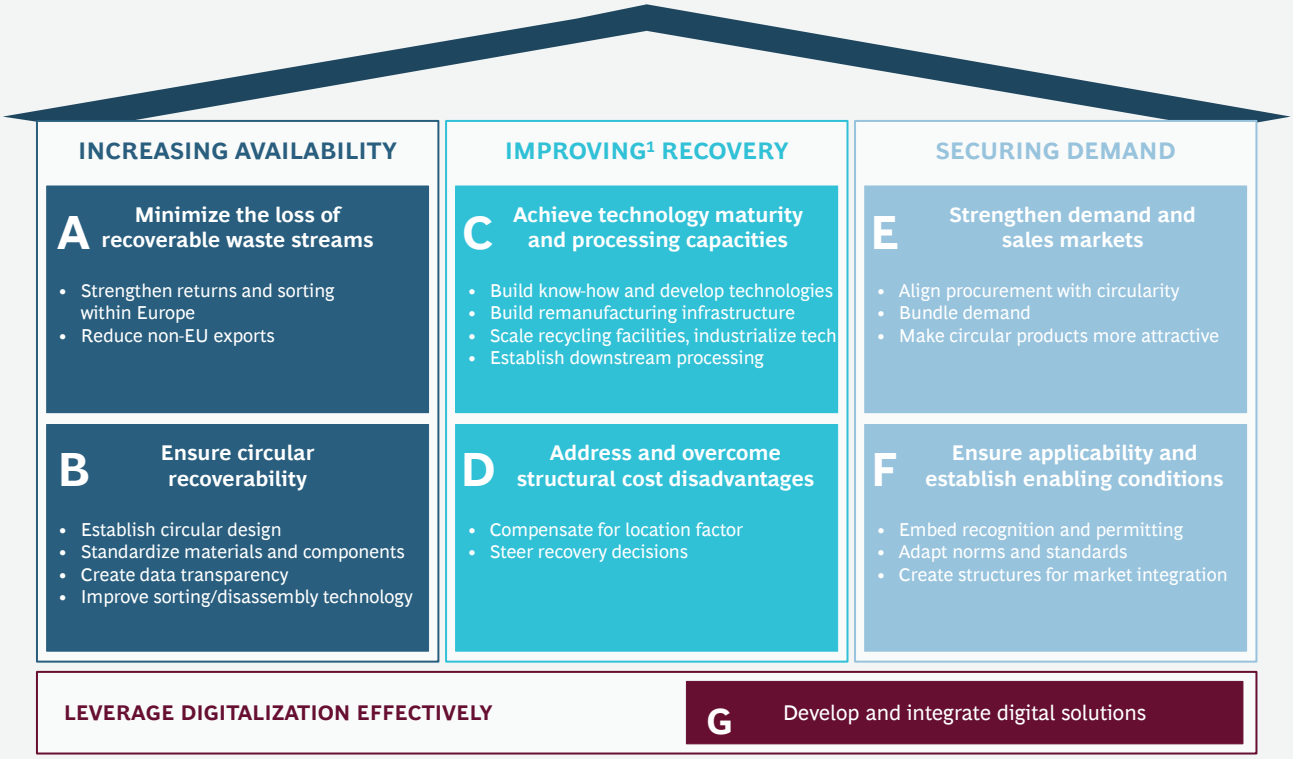
The key driver for implementing these levers is expanding collection and domestic sorting. Realizing this potential requires both the development of scaled infrastructure and secure demand for recyclates and reusable products. In addition to expanding and advancing sorting and *recycling* capacities, it is therefore crucial to strengthen stable markets, in particular, to ensure that circular business models are economically viable.

The economic and ecological potential described as well as bolstering competitiveness can be achieved within existing value creation structures. However, collective action by industry and policymakers is required in seven action areas. Successfully scaling the circular economy can only succeed if competitiveness is ensured both in terms of primary production and in international comparison. The measures developed meet these requirements and are targeted at the aforementioned strengthening of gross value added and resilience. The seven action areas address boosting material and product availability for the application of different "R" strategies, improving recovery processes, securing demand for circular products, and increasing the use of digital solutions.

For effective implementation, contributions from industry are required in the respective spheres of influence as well as critical reflection and advancement of the political framework (such as through suitable incentive mechanisms, reliable guardrails, and targeted funding instruments). On the company side, ambitious circularity targets and building up specific expertise are key, as are partnerships within industry and with research institutions to increase innovation capacity. To unlock the macroeconomic potential and ensure operational resilience and competitiveness, strategic intent is required—both in companies' target setting and in public policymaking.

Implementing the roadmap requires cumulative one-time investments totaling approximately €20 billion by 2045. Spread over the investment period, this corresponds to 3–4% of the annual investment volume in circular-economy-adjacent segments. The largest share, around €8 billion, is for expanding recycling infrastructure. Further investments are necessary for building *remanufacturing* and *refurbishment* structures as well as digital infrastructure (such as the Digital Product Passport), and also for design adaptations and application-oriented research (for example, on circular materials and *recycling* technologies). A substantial part of the investments will be borne by industry. For this to contribute to competitiveness in the long term, investments must not only be economically attractive but also strategically meaningful and predictable. Whether these investments are made depends not only on economic viability but also on the speed of implementation and the reliability and clarity of the policy framework. Overall, the required investments can pay off at the macroeconomic level in just a few years, given the gross value added unleashed by the circular economy.

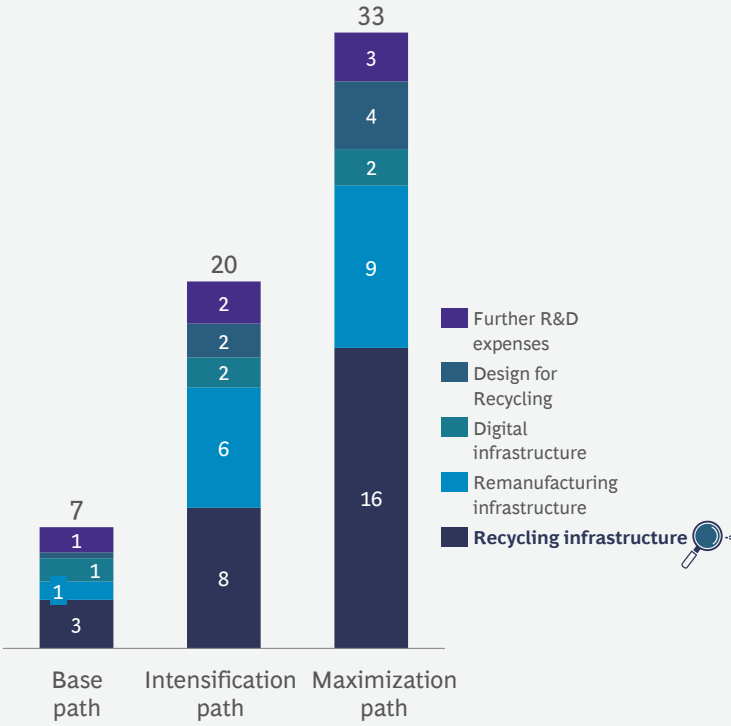
A competitive circular economy requires collective action by industry and policymakers along seven action areas



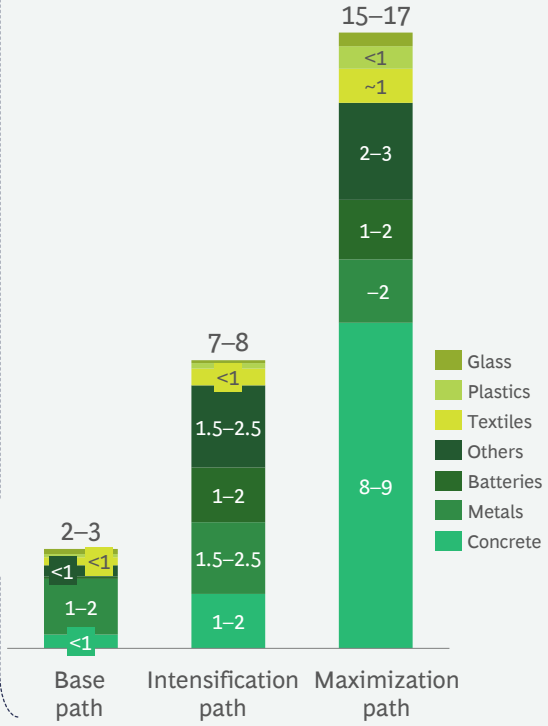
1. Incl. preparation for reuse as per KrWG §3, par. 23a
Source: BCG analysis

Implementation of the action areas requires cumulative one-off investments of around €20B by 2045; with recycling infrastructure being the largest share

Investment requirements to implement circularity levers
In B€, cumulative through 2045



Recycling infrastructure by material
Cumulative through 2045, in B€



The transformation requires companies to take decisive action. There are already numerous reports summarizing the crucial action areas (WBCSD and BCG 2018, 2019, 2022). They consistently show that scaling the circular economy can only succeed if it is anchored in the agenda of top management. Essential elements include operationalization via clear targets, a few controllable KPIs, and robust governance, as well as translating that into viable investment and business models through prioritized material and product clusters.

From the existing reports and the case studies listed in this report, we derived the eight most important steps for companies to take. Making the circular economy a reality will require an interplay of various players along entire value creation cycles—from identifying key design options (including standardization and harmonization) to procurement and reverse logistics to the reprocessing or recovery process. Despite company-specific differences, decisive success factors can be identified that support effective and scalable implementation. They indicate how corporate action can be effectively aligned with strategy, organization, and execution.

The Circular Economy Roadmap is a building block of the transformative value creation agenda for German industry. Despite different starting points in the individual segments, Germany has all the conditions to turn an ambitious circular economy into a location advantage and, as an export nation, to sustainably strengthen its international competitiveness: technology leadership in circular value creation, a strong industrial base with basic materials and process industries as central system building blocks, and broad societal and corporate acceptance for circular business models. As a systemic approach, the circular economy combines economic performance, increased strategic autonomy, and climate protection, thus enabling it to become a cornerstone of a future-ready German industry.

To leverage the benefits of the circular economy, decisive action is required on the part of companies

Eight steps for embedding the circular economy within companies

1. Anchor circularity in the **competitiveness and resilience agenda** of top management
2. **Define a clear target** for circularity and communicate it group-wide
3. Quantify ambitions and translate them into a limited selection of **manageable KPIs**
4. Define **governance and responsibilities** along the value creation cycle
5. Select **priority material/product clusters** and consistently fine-tune levers of the circular economy
6. Establish and safeguard **business cases** and **innovation** for prioritized levers (incl. continuous technology improvement)
7. Scale **AI** and **digital solutions** as enablers and integrate them into core processes
8. Establish **partnerships** and **ecosystems**: Make value pools transparent and distribute them fairly

The Full Report

This publication provides targeted insight into one of the most pressing economic and resource-policy issues of our time. The long version of the study encompasses the full picture: with sound analyses, detailed modeling, comprehensive data, and specific recommendations for action for decision-makers in politics, business, and society.

We invite you to take a closer look:

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