BOSTON CONSULTING GROUP

The Business Case for Circular Metals

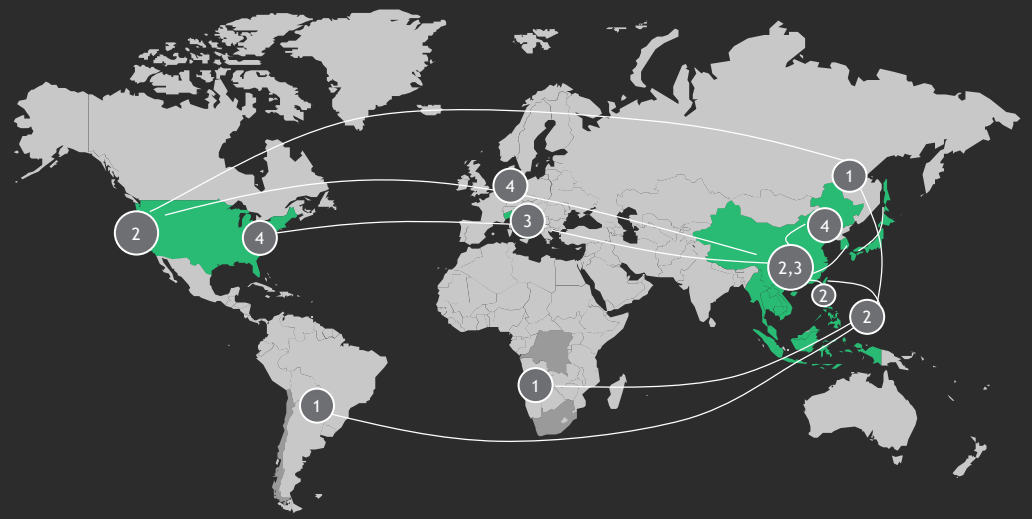
Unlocking value - Using the example of the Circular Economy for German Industry

JUNE 2026

E-WASTE WORLD EXPO
BATTERY RECYCLING EXPO
METAL RECYCLING EXPO
ITAD & CIRCULAR ELECTRONICS EXPO

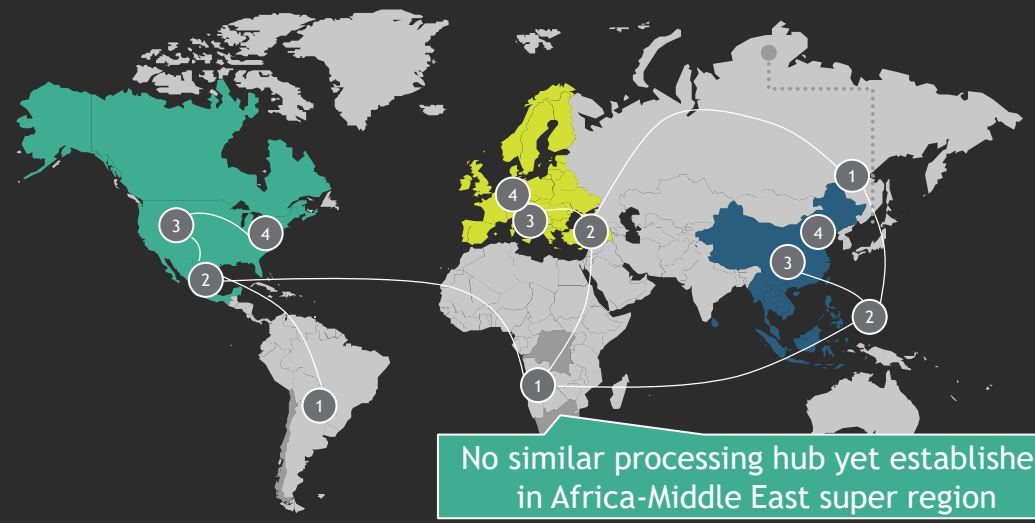
Geopolitical stresses are reshaping global trade flows as countries adopt more protectionist policies

Post Cold-War: Complex, global value chains based on global free trade/market access



- Component and part assembly spread across the globe
- Intercontinental final customer delivery after final assembly
  - ⊕ Leverage of material and labor cost arbitrage
  - ⊖ Complex and global logistics chains, exposed to disruptions

New normal: Value chains centered around regional clusters and trade blocs



- Near-shoring of relevant components and assemblies regionally
- Unchanged origins of raw material sourcing
  - ⊕ Reduced supply chain complexity
  - ⊖ Limited exploitation of globally optimal cost factors

(1) Raw materials (2) Components and part assemblies (3) Final assembly (4) Final customer delivery

Note: Sample supply chain
Source: BCG research

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Strong import dependence and supply uncertainties are putting Germany's international competitiveness under pressure

~100%

Import Dependence

Nearly 100% of key materials for future technologies come from foreign sources

>40%

Price Volatility

Prices of key raw materials fluctuate by >40% within a year (e.g., copper, silver, lithium)[1]

20-40%

Recovery

Recycling & reuse can replace 20-40% of strategic raw material imports by 2045

1. e.g., Lithium > 400% (2021/2022), Silver +41% (2024/2025), Copper +51% (2020/2021) | Source: BCG analysis

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The Circular Economy makes industry more resilient while increasing value creation in Germany

Circular gross value added can more than double from today's € 60 bn to up to € 125 bn in 2045

The identified circular levers can generate cumulative € 700 to 880 bn in gross value added by 2045

Import dependence can decline significantly – by up to 20 percent for rare earths, and by up to 10 percent for battery materials

Potential can be unlocked within existing industrial and value chain structures

Implementation requires one-time investments of ~€ 20 bn into the core structures of the circular Economy

Companies can benefit from higher margins, market potential and resilience

>5%p.

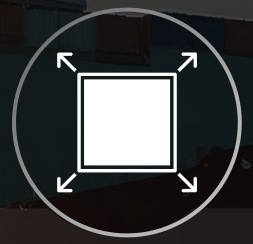
Margin potential

by reducing manufacturing costs by ~60-70% in remanufacturing and refurbishment business models vs. conventional new production

-15%

Material cost reduction

through strategic material sourcing, optimized product design and improved process efficiency



>€150 bn

Global market potential

for recycling facilities and software for the Circular Economy worldwide in 2045, with >5% annual growth

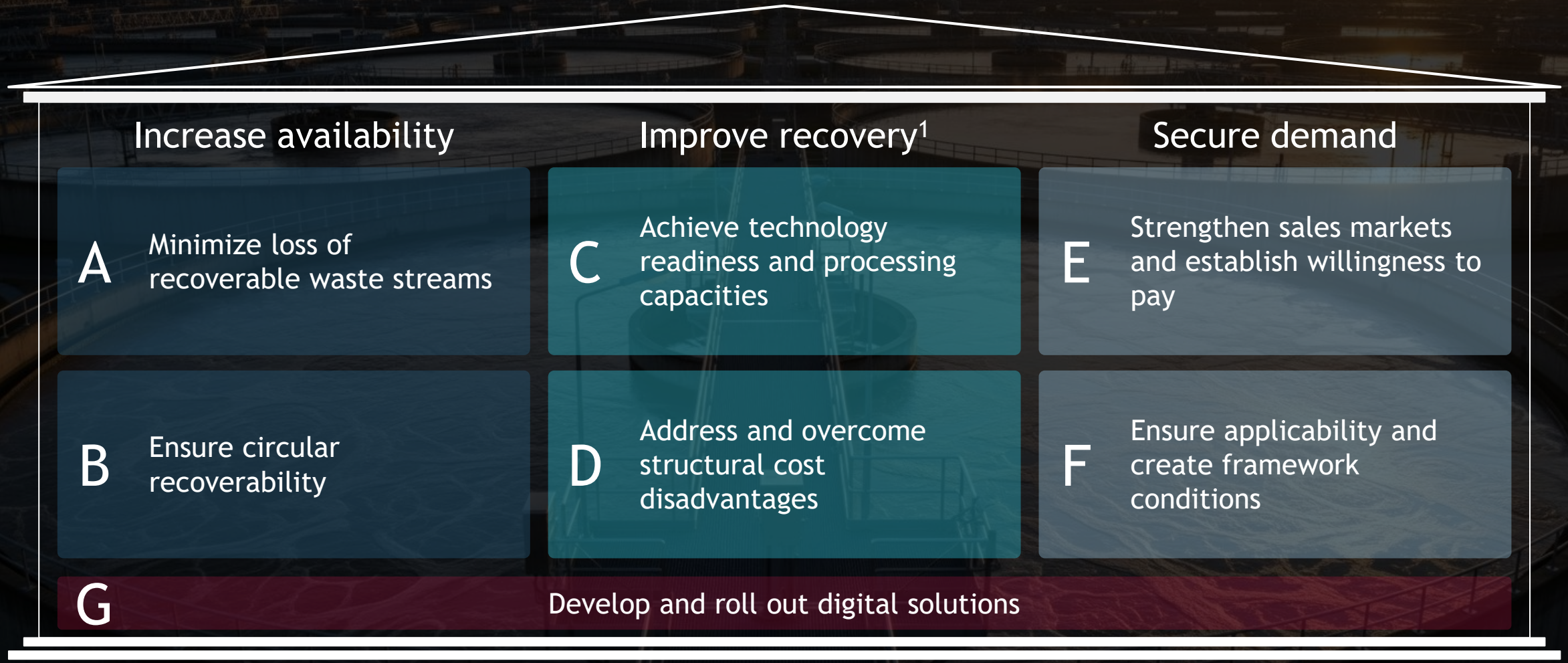
~2%

Additional emission reduction

equivalent to ~11 Mt CO_2e p.a. by 2045 – ~2% of Germany's total emissions – from identified levers in production and end-of-life along global value chains

Sources: BDI/VDMA survey, kei, TSR, Destatis

For a competitive circular economy, collective action by industry and policymakers is needed along seven action fields



1. Incl. preparation for reuse pursuant to §3, para. 23a, German Circular Economy Act (BMUKN 2024)
Source: BCG analysis

For a competitive circular economy, collective action by industry and policymakers is needed along seven action fields

Increase availability

A Minimize loss of recoverable waste streams

- Strengthen return logistics and sorting within Europe
- Reduce non-EU exports

B Ensure circular recoverability

- Establish design for circularity
- Standardize materials and components
- Create data transparency
- Improve sorting technology

Improve recovery[1]

C Achieve technology readiness and processing capacities

- Develop know-how and technologies
- Build remanufacturing infrastructure
- Scale facilities, industrialize technologies
- Establish downstream processing

D Address and overcome structural cost disadvantages

- Compensate for location factors
- Steer recovery decisions

Secure demand

E Strengthen sales markets and establish willingness to pay

- Align procurement with circularity
- Bundle demand
- Make circular products more attractive

F Ensure applicability and create framework conditions

- Anchor recognition and approval
- Adapt norms & standards
- Create structures for market integration

Deploy technology effectively

G Develop and roll out digital solutions

1. Incl. preparation for reuse pursuant to §3, para. 23a, German Circular Economy Act (BMUKN 2024)
Source: BCG analysis

Top circular levers and GVA potential by 2045

Mobility

€ 5 - 9 bn

GVA potential by 2045

- Reuse & remanufacturing of passenger vehicle components
- Battery recycling for critical raw materials (Li, Ni, Co)
- Increase vehicle recycling (steel, aluminum, copper)

Mechanical Engineering

€ 25 - 32 bn

GVA potential by 2045

- Remanufacturing & refurbishment of equipment
- Equipment for sorting, disassembly & recycling
- Digital upgrades for Circular Economy requirements

Construction

€ 17 - 21 bn

GVA potential by 2045

- Refurbishment of existing buildings instead of new construction
- Increase recycling volumes of construction materials
- Improved sorting & processing of recyclates

Energy

€ 3 - 4 bn

GVA potential by 2045

- Recycling of wind, PV & batteries (critical raw materials)
- Refurbishment of grid & wind power components
- Second-life EV batteries as stationary storage

Textiles

€ 3 - 8 bn

GVA potential by 2045

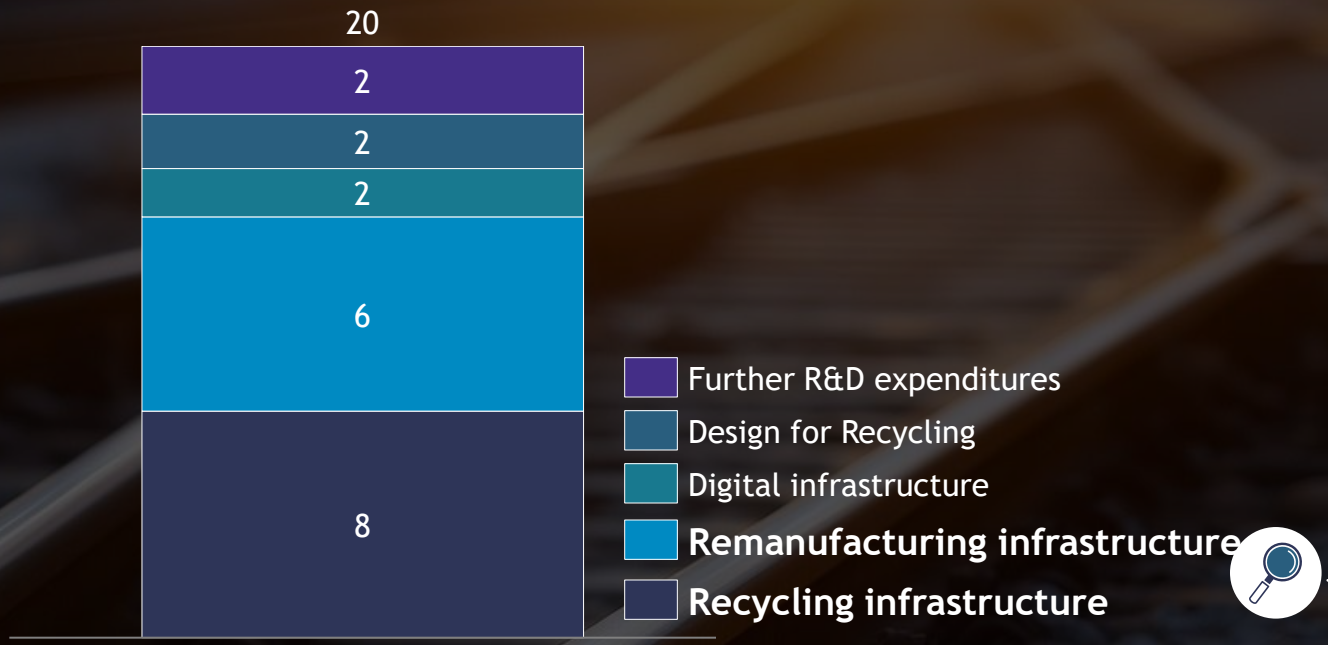
- Increase resale share (lifetime extension)
- Textile recycling for spinnable fibers (fiber-to-fiber)
- Expand domestic sorting, reduce exports to non-EU

Source: BCG-BDI Circular Economy Study (2026) | Figures: Intensification path (low) to Maximization path (high)

Around € 20 bn in one-time investments by 2045 as a lever for value creation & location development – with a focus on recycling & remanufacturing infrastructure

Investment needs for implementing circular levers

in € bn, cumulative by 2045



Key investment needs

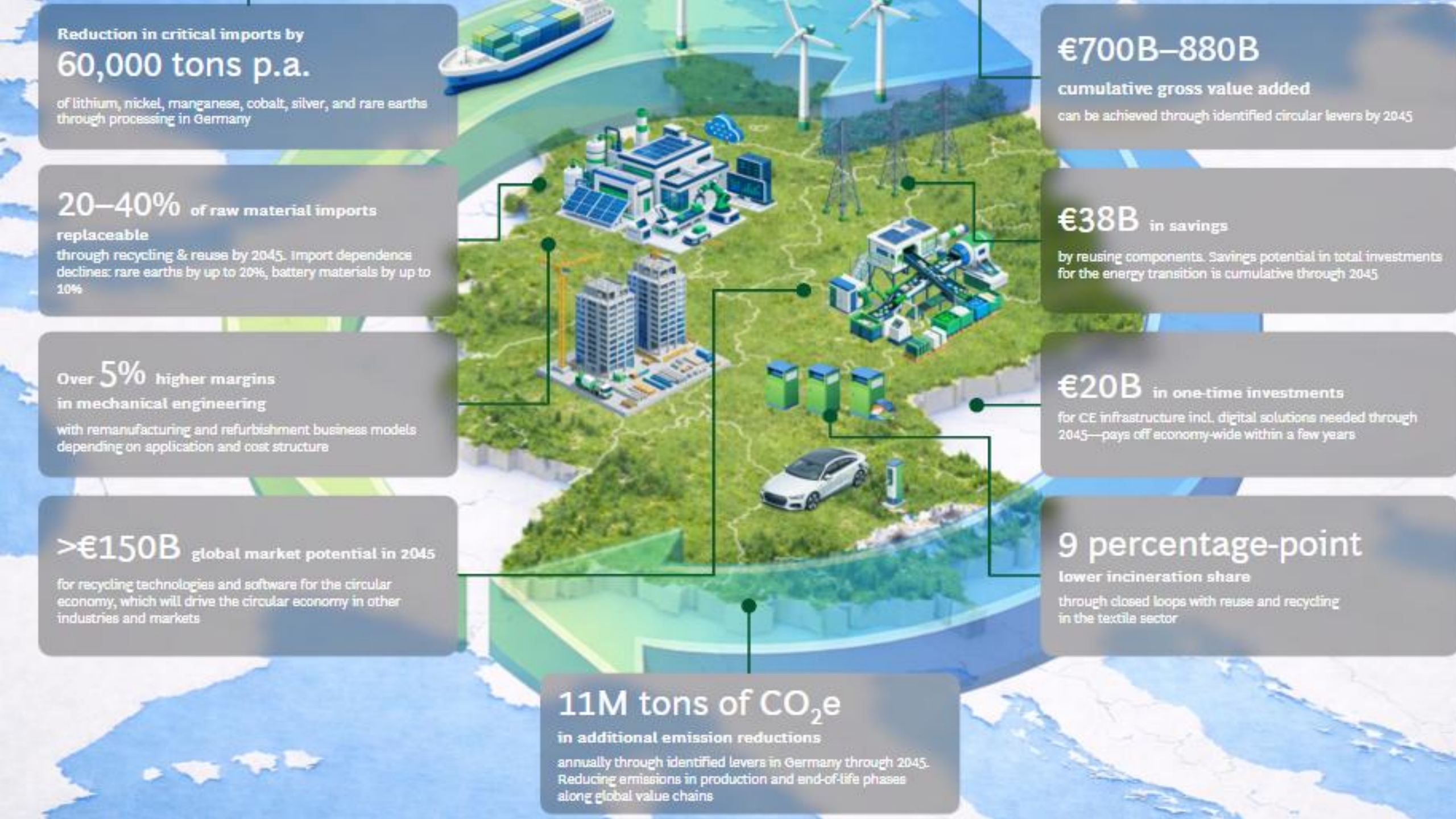
Remanufacturing infrastructure

- **Processes:** Disassembly, cleaning and testing capacities
- **Facilities:** e.g., specific production lines
- **Systems:** Logistics and IT for industrial reprocessing of products, equipment, etc.

Recycling infrastructure

- **Batteries:** Hydrometallurgy for processing
- **Metals:** Magnet-to-magnet processes, photovoltaic recycling
- **Concrete:** Recyclates as aggregate substitute

Note: Operating costs of companies, such as any production line conversions, are not included.



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 & 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

Looking forward to making circularity work

Study created together with Germany's leading

BDI BCG BOSTON CONSULTING GROUP WBCSD World Business Council for Sustainable Development

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