STRATEGIC WHITE PAPER

Circular economy as a strategic opportunity for Europe's electronics industry

How Circular Electronics Could Strengthen Europe's Competitiveness, Supply Chain Resilience and Electronics Manufacturing

Author	Organisation	Version	Character
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Introduction

For years, Europe has debated the same strategic challenges—often in isolation. The European Chips Act, supply chain resilience, reshoring and nearshoring, critical raw materials, ESG requirements, and the circular economy are typically discussed within separate regulatory, industrial, and political frameworks. What has largely been missing is a broader perspective that examines how these developments may reinforce one another.

This Strategic White Paper takes precisely that perspective. It does not claim to establish a new causal relationship or replace existing scientific research. Instead, it explores an industrial policy question: **Could Europe create an additional competitive advantage by strategically connecting its strengths in circular economy, remanufacturing, material recovery, electronics manufacturing services (EMS), and printed circuit board (PCB) production?**

The repeated use of the word **"could"** throughout this paper is intentional. The objective is not to predict future developments, but to present a strategic perspective that encourages discussion and further analysis.

The following chapters combine established facts with logically derived conclusions. Wherever statements are supported by existing studies, they are referenced accordingly. Where relationships have not yet been examined in the available literature, they are explicitly identified as strategic considerations developed by EMS Strategy Group. This paper should therefore be understood as a contribution to the ongoing industrial policy debate rather than as definitive scientific proof.

1. The starting point: Five developments, one strategic opportunity

Several European policy initiatives currently pursue similar overarching objectives: strengthening industrial competitiveness, reducing strategic dependencies, securing critical resources, and building more resilient value chains within Europe. Yet these initiatives have largely evolved independently and are often discussed within separate political, regulatory, and technical contexts.

The European Chips Act 2.0

In June 2026, the European Commission presented its proposal for the European Chips Act 2.0, building upon the original Chips Act, which has already mobilised more than €52 billion in public and private investments. The initiative responds to Europe's comparatively small share of global semiconductor manufacturing and its continued dependence on non-European suppliers in strategically important technologies. One notable addition concerns public procurement, where, under certain conditions, preference may be given to companies established within the European Union and controlled by EU-based entities. [1][2][3]

The Industrial Decarbonisation Accelerator Act

Presented by the European Commission in March 2026, the Industrial Decarbonisation Accelerator Act aims to strengthen Europe's industrial base by retaining a greater share of value creation within the region. Among other measures, the proposal introduces local value creation criteria for strategic funding programmes and selected public procurement activities. The initiative responds to the long-

term decline of manufacturing as a share of European gross domestic product and seeks to reinforce Europe's industrial competitiveness. [5][19]

The Critical Raw Materials Act

Since entering into force in 2024, the Critical Raw Materials Act has established concrete targets to reduce Europe's dependence on strategically important raw materials. By 2030, at least 25 percent of the EU's annual consumption of strategic raw materials should originate from recycling, while domestic extraction, processing, and refining capacities are to be significantly expanded. In 2025, the European Commission already approved numerous Strategic Projects intended to accelerate implementation across the Member States. [8][9]

The Circular Economy Act

The proposed Circular Economy Act seeks to establish a functioning European market for secondary raw materials and further strengthen circular value chains across the European Union. As part of the Clean Industrial Deal, the initiative aims to significantly increase Europe's circular material use rate while improving resource efficiency and reducing dependence on imported raw materials. [10]

ESG and Supply Chain Requirements

At the same time, ESG reporting obligations, sustainability regulations, and supply chain due diligence requirements are increasingly influencing the selection of suppliers and manufacturing partners. Transparency, carbon footprint, material origin, traceability, and responsible sourcing are becoming strategic procurement criteria alongside traditional considerations such as cost, quality, and delivery performance.

Each of these initiatives addresses a specific policy objective. This Strategic White Paper therefore does not evaluate the individual measures themselves. Instead, it examines a broader strategic question:

Could the combined effect of these developments create a new long-term competitive advantage for Europe's electronics industry?

This question forms the foundation of the analysis presented in the following chapters.

2. A Strategic Logic: How These Developments Could Reinforce One Another

The central idea of this Strategic White Paper cannot be reduced to a single statement or policy recommendation. Instead, it proposes a strategic logic in which several developments that are already observable today could reinforce one another over time. Whether these interactions will ultimately materialise in practice cannot yet be empirically verified. For this reason, the following considerations should be understood as a strategic perspective rather than a proven cause-and-effect relationship.

The starting point is Europe's electronics manufacturing industry. At the end of their service life, electronic assemblies re-enter the value chain as field returns, production rejects, warranty returns, or end-of-life products. At this stage, a decision can be made whether an assembly or individual components are technically and economically suitable for remanufacturing or whether the embedded materials should instead be recovered through recycling.

Where remanufacturing is feasible, electronic assemblies or selected components can be restored and returned to productive use, extending product life cycles and preserving value. Where this is not practical, valuable raw materials—including copper, gold, palladium, silver, and tin—can be recovered and reintroduced into industrial value chains as secondary raw materials.

If these secondary raw materials become increasingly available within Europe, they could strengthen the region's industrial resource base over the long term. This could benefit printed circuit board (PCB) manufacturers, material suppliers, chemical companies, recyclers, EMS providers, and other participants across the European electronics value chain. A stronger regional supply base could, in turn, improve the competitiveness, resilience, and supply security of European electronics manufacturing.

Should this lead to a growing share of electronics manufacturing being sourced within Europe, the future availability of products suitable for remanufacturing, recycling, and material recovery would likewise increase. This would create a reinforcing industrial cycle that extends beyond recycling alone. Its strategic value would result from the interaction of manufacturing, circular economy, secondary raw materials, industrial capabilities, and long-term sourcing decisions.

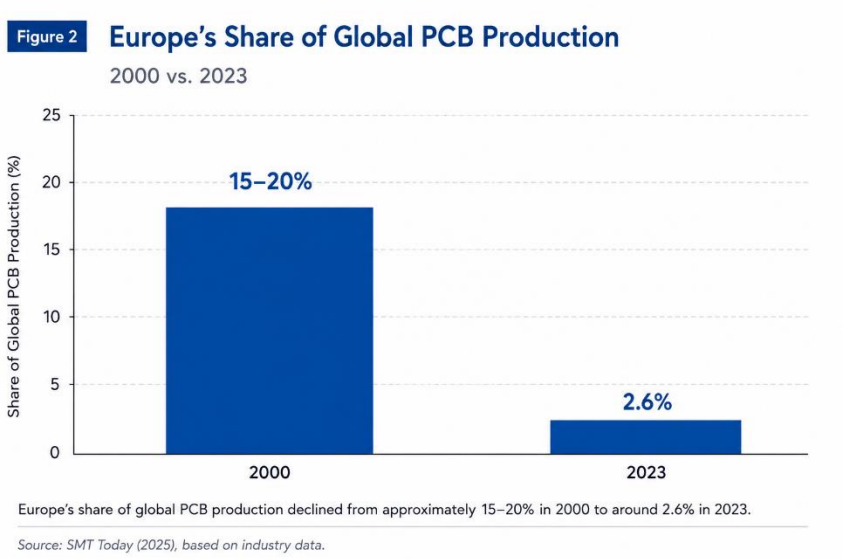
Additional developments could further strengthen this effect. A higher availability of European secondary raw materials could reduce strategic dependence on imported resources while improving supply chain resilience. At the same time, regulatory initiatives, increasing sustainability requirements, the Digital Product Passport (DPP), and a broader interpretation of Total Cost of Ownership (TCO) could gradually encourage procurement decisions that take long-term value creation into greater account. None of these developments alone is likely to transform Europe's competitiveness. However, their combined effect could contribute to a stronger and more resilient European electronics industry.

The following chapters examine each element of this strategic logic individually. For every aspect, the paper distinguishes between established facts, existing evidence, identified limitations, and strategic considerations where further research or practical experience will be required.

3. Europe's Declining Manufacturing Base: The Starting Point

Before examining the potential role of a more integrated circular economy, it is important to understand the current state of Europe's electronics manufacturing industry. Available market data shows a long-term decline in key manufacturing capacities across Europe, increasing the region's dependence on global supply chains in several strategically important areas.

This trend is particularly evident in the printed circuit board (PCB) industry—one of the fundamental technologies underpinning virtually all electronic products. Europe's share of global PCB production declined from approximately **15–20% in 2000** to only **around 2.6% in 2023**. Over the same period, China significantly expanded its position and today accounts for approximately **58.7% of global PCB production**. Even in strategically important sectors, Europe's dependence has become increasingly apparent. It is estimated that around **60% of the printed circuit boards used in European defence applications** are sourced from manufacturers outside Europe. [15]



Other indicators confirm this long-term structural trend. Between 2015 and 2021, the number of PCB manufacturers operating in Europe declined from **247 to 171 companies**. During the same period, Europe's share of global PCB sales remained comparatively modest. Although production share and sales share are not directly comparable metrics, both point to the same conclusion: Europe's manufacturing base has steadily lost global significance over the past two decades. [14]

A similar pattern can be observed in the semiconductor industry. Europe continues to account for **less than 10% of global semiconductor production**, despite semiconductors representing one of the world's most strategically important technologies. Although semiconductors and printed circuit boards occupy different stages of the electronics value chain, together they illustrate Europe's structural dependence in critical areas of electronics manufacturing.

The reasons for this development extend far beyond labour costs. Global production ecosystems, economies of scale, investment patterns, supply chain concentration, industrial policy, and long-term strategic investments have all contributed to today's market structure.

One often-overlooked factor is Europe's customs framework. While finished printed circuit boards imported from China generally enter the European Union without import duties, several raw materials and intermediate products required by European PCB manufacturers remain subject to import tariffs of up to **6.5%**. This imbalance has been highlighted within the European Parliament, as it may unintentionally disadvantage domestic manufacturing compared with imported finished products. Although the issue was formally raised in 2023, no fundamental adjustment has been implemented to date. [16]

Taken together, these developments illustrate more than the gradual decline of Europe's manufacturing capacity. They also demonstrate that industrial competitiveness is shaped not only by global market forces, but equally by regulatory frameworks, investment decisions, industrial capabilities, and supply chain structures.

This observation forms the starting point for the strategic considerations presented in this White Paper. If Europe seeks to strengthen its electronics industry over the long term, the relevant question is no longer whether individual policy initiatives are justified. Rather, it is whether the interaction of industrial policy, circular economy, raw material security, manufacturing capabilities, and strategic sourcing decisions could create an additional competitive advantage for European electronics manufacturing.

4. The Existing Foundation: What Happens to End-of-Life Electronics?

Every year, millions of tonnes of electrical and electronic equipment are placed on the European market. In 2023, the total volume exceeded **14.4 million tonnes**—an increase of approximately **89%** compared with 2012. Yet only **5.2 million tonnes** were officially collected as waste electrical and electronic equipment (WEEE), corresponding to an EU collection rate of **37.5%**. In Germany, the collection rate was even lower at **29.5%**. [11]

These figures illustrate a significant challenge: a substantial share of valuable materials remains outside documented collection and recycling systems. As a result, considerable quantities of strategically important raw materials are lost each year instead of being returned to industrial value chains.

According to the European Commission, the approximately **10.7 million tonnes** of e-waste generated within the European Union in 2022 contained an estimated **one million tonnes of critical raw materials**, including around **162,000 tonnes of copper**, **208,000 tonnes of aluminium**, and approximately **two tonnes of palladium**. However, only around **0.4 million tonnes** of these critical materials were actually recovered. [12]

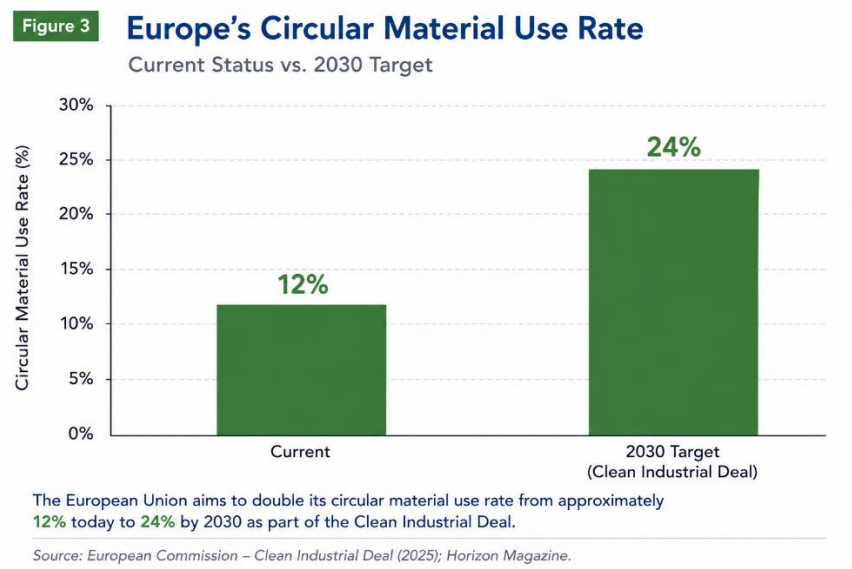
At the same time, Europe already possesses advanced industrial capabilities for recovering valuable materials from electronic waste. A well-known example is **Umicore's** precious metals refinery in Antwerp, Belgium, one of the world's leading facilities for recovering gold, silver, platinum-group metals, copper, and other valuable materials from complex electronic scrap. Such facilities

demonstrate that the technological foundation for high-quality material recovery is already available within Europe.

The economic significance of this so-called **"urban mine"** is frequently underestimated. According to an independent scientific study, the annual global sales of mobile phones and computers alone contain the equivalent of approximately **3% of worldwide gold production**, around **15% of global palladium production**, and more than **20% of global cobalt production**. End-of-life electronics therefore already represent an important secondary source of strategically relevant raw materials. [13]

The principal challenge therefore lies less in recycling technology itself than in connecting the individual stages of the value chain. The key objective is to ensure that a larger proportion of end-of-life electronic products is systematically collected, professionally processed, and returned to industrial production as high-quality secondary raw materials.

This is precisely where current European policy initiatives converge. The **Critical Raw Materials Act** aims for at least **25% of the EU's annual consumption of strategic raw materials** to originate from recycling by 2030. At the same time, the proposed **Circular Economy Act** seeks to establish a stronger European market for secondary raw materials and improve the integration of recovered materials into industrial value chains. Together with the objectives of the **Clean Industrial Deal**, these initiatives are intended to significantly increase Europe's circular material use rate over the coming years. [8][10]



Taken together, these developments demonstrate that many of the essential building blocks of a European circular economy already exist. Europe possesses advanced recycling technologies, established industrial capabilities, and increasingly supportive regulatory frameworks. The greatest remaining potential lies in increasing collection rates, improving material recovery, and integrating secondary raw materials more consistently into Europe's electronics manufacturing value chain.

This distinction is important. The strategic challenge is no longer whether Europe can recover valuable materials from electronic products. The more relevant question is whether these recovered materials can increasingly become part of a resilient European electronics ecosystem that strengthens industrial competitiveness, supply chain resilience, and long-term value creation.

5. From Secondary Raw Materials to Industrial Value Creation

At this point, the analysis moves beyond directly verifiable market observations and considers a broader strategic perspective. While individual elements of the following argument are supported by existing studies and regulatory developments, no comprehensive scientific model currently describes their combined economic interaction. The following considerations should therefore be understood as a plausible strategic scenario rather than an empirically verified cause-and-effect relationship.

A greater availability of high-quality secondary raw materials within Europe could strengthen the long-term resource base of European manufacturers. The primary benefit is not necessarily lower global commodity prices, but rather reduced dependence on imported primary raw materials, improved supply security, shorter transport distances, and greater resilience of regional supply chains. Depending on the product, material, and market environment, these factors could improve the competitiveness of European manufacturers across the electronics value chain.

A stronger regional supply of secondary raw materials could benefit printed circuit board (PCB) manufacturers, laminate and material suppliers, chemical companies, recyclers, and other upstream industries. As these industrial capabilities develop, they could also enhance the competitiveness of European Electronics Manufacturing Services (EMS) providers by strengthening the surrounding manufacturing ecosystem.

The strategic significance of this development lies less in relocating existing production facilities than in influencing future manufacturing sourcing decisions.

This distinction is important. OEMs do not need to relocate their own factories in order to increase manufacturing activities within Europe. In many cases, electronics manufacturing is outsourced to EMS providers. While relocating an existing manufacturing site typically requires substantial investments, lengthy implementation periods, and significant operational risk, awarding future production programmes to a European EMS provider can often be decided considerably faster, depending on product life cycles, sourcing strategies, and contract renewal periods.

At the same time, Europe's regulatory environment is evolving. Through initiatives such as the **Industrial Decarbonisation Accelerator Act** and the **European Chips Act 2.0**, the European Union seeks to strengthen regional value creation by introducing local value creation criteria for strategic funding programmes and selected public procurement activities. These measures have the potential to influence future sourcing decisions independently of pure manufacturing costs. [4][5]

Market developments point in the same direction. Industry studies indicate that procurement requirements for EMS providers are evolving. Supply chain resilience, sustainability performance, regional manufacturing capabilities, dual sourcing strategies, ESG compliance, Scope 3 emissions, and long-term supply security are becoming increasingly important evaluation criteria. For many OEMs, manufacturing partner selection is gradually shifting from a predominantly unit-price-based decision towards a broader Total Cost of Ownership (TCO) assessment that considers strategic and operational risks alongside production costs. [17][18]

Taken together, these developments suggest a possible strategic interaction. A stronger European circular economy could improve the regional availability of secondary raw materials. At the same time, evolving industrial policies, changing procurement criteria, and increasing emphasis on resilient regional supply chains could further strengthen the attractiveness of European manufacturing.

Whether these factors will ultimately be sufficient to influence manufacturing sourcing decisions on a broader scale cannot currently be demonstrated empirically. However, viewed collectively, they represent a credible strategic perspective that may become increasingly relevant as Europe's industrial policy, circular economy, and electronics manufacturing capabilities continue to evolve.

6. A Strategic Consideration: Could Material Recovery Become Part of Future TCO Assessments?

At this point, the analysis deliberately moves beyond verifiable market observations and introduces an original strategic consideration developed by EMS Strategy Group. During the research for this White Paper, no published literature was identified that examines the relationship described below in a comparable way or integrates it into existing Total Cost of Ownership (TCO) models. The following discussion should therefore be understood as a strategic contribution to the debate and as a possible direction for the future development of TCO methodologies.

For many years, Total Cost of Ownership (TCO) models have been widely used in electronics manufacturing to support sourcing and manufacturing decisions. They typically evaluate procurement, production, logistics, quality, operational, and end-of-life costs. A notable observation, however, is that end-of-life activities are almost exclusively treated as cost factors—for example, disassembly, data destruction, transportation, recycling, or disposal. By contrast, the potential economic value generated through the future recovery of materials, components, or assemblies is rarely considered as part of the original manufacturing sourcing decision. [20][21]

Strategic Consideration by EMS Strategy Group

If an OEM were to outsource electronics manufacturing to a European EMS provider that is already integrated into established take-back, remanufacturing, and recycling networks, the subsequent recovery of materials could potentially be organised more efficiently than within globally dispersed supply chains. Shorter transportation distances, harmonised regulatory frameworks, and existing European recycling and processing infrastructures could contribute to a more transparent, efficient, and economically attractive recovery process.

This leads to a strategic question:

Should the potential economic value of future material recovery—including recovered materials, assemblies, and critical raw materials—be considered as an additional element in future Total Cost of Ownership (TCO) assessments?

This consideration does **not** suggest that manufacturing in Europe would automatically become more cost-competitive. Rather, it raises the question of whether future TCO models could be expanded to include a value component that has so far received little attention: the potential residual value of products, components, and materials at the end of their service life.

The gradual development of Europe's circular economy may provide the information required to support such assessments. One important enabler is the **Digital Product**

Passport (DPP), introduced as part of the European Union's sustainability and circular economy strategy. By providing digital information on material composition, components, repairs, and product life cycles, the DPP could establish a more robust foundation for evaluating reuse potential, material recovery, and residual values as part of future economic decision-making.

The foundation for these future residual values, however, is established much earlier—during product development. Whether electronic assemblies can be economically disassembled, repaired, remanufactured, or recycled five, ten, or even more years after production is largely determined during the design phase. **Design for Circularity** therefore aims to develop electronic products in ways that facilitate future recovery through modular architectures, accessible components, standardised joining technologies, and material choices that simplify separation and recycling. In this sense, the economic value of circular business models is created not only at the end of a product's life cycle, but already during its development. This also highlights the growing importance of close collaboration between OEM development teams and EMS providers in designing products that support future circular value creation.

Should reliable methods for assessing material recovery and residual values become available, entirely new business models could emerge. Financial institutions, for example, could develop leasing or pay-per-use concepts that partially reflect the remaining material value of electronic products. Likewise, insurance providers could eventually offer products that insure defined residual values or certified remanufacturing concepts, thereby reducing investment risk and creating additional incentives for circular business models. While these concepts remain largely theoretical today, they illustrate that the circular economy may eventually influence not only manufacturing and sustainability, but also financing, investment, and procurement strategies.

However, this strategic consideration is subject to several important limitations.

First, the achievable economic value depends on numerous variables, including product design, material composition, future commodity prices, the technical suitability of components for reuse, and the availability of efficient collection, remanufacturing, and recycling infrastructures.

Second, no generally accepted methodology currently exists for integrating future material recovery or residual values into Total Cost of Ownership models. Any future valuation framework would need to combine technical, economic, regulatory, and market-related parameters.

Third, procurement decisions are still primarily driven by short- and medium-term financial objectives. Potential economic benefits that may only materialise several years after production typically receive less attention than immediate and measurable cost savings.

Finally, the practical relevance of such valuation approaches will depend on future developments in regulation, commodity markets, technology, and industrial capabilities. As circular economy infrastructures mature, complementary financing models, leasing concepts, and insurance solutions could provide additional incentives to incorporate long-term material value into strategic sourcing decisions.

Against this background, this chapter should not be interpreted as evidence of an established economic relationship. Instead, it presents a strategic evaluation concept that may gain relevance as circular economy policies, remanufacturing, critical raw material strategies, digital product information, and European industrial capabilities continue to evolve. Whether this ultimately leads

to new procurement evaluation criteria remains an open question that will require both practical experience and further academic research.

7. Risk Assessment: Key Challenges and Their Implications

Every strategic concept must ultimately be assessed against its practical feasibility. The strategic logic presented in this White Paper is no exception. Whether circular economy principles, remanufacturing, and material recovery can be integrated successfully into Europe's electronics industry depends on numerous technical, economic, regulatory, and organisational factors.

The following challenges are frequently raised by OEMs, EMS providers, procurement organisations, and quality managers. They represent legitimate considerations and deserve an objective assessment.

7.1 At the Beginning of a Product Life Cycle, There Are No Products to Recover

This objection is entirely valid. During the introduction phase of a product, no meaningful return volumes are available for remanufacturing or material recovery. Consequently, the strategic logic described in this White Paper cannot be applied to individual products or the launch of a new production programme.

Its potential develops over multiple product generations, as maintenance activities, upgrades, repairs, and field returns gradually create continuous flows of products, components, and materials. The concept therefore focuses on long-term product portfolios and industrial value creation rather than on individual product launches.

7.2 Reverse Logistics Creates Additional Costs

This objection is equally justified. Collecting, sorting, testing, disassembling, transporting, and processing end-of-life electronics inevitably requires additional resources and is inherently more complex than supplying production with virgin materials.

At the same time, Europe's regulatory framework is evolving. Since the revised EU Waste Shipment Regulation entered into force in 2024, regional collection, processing, and recycling infrastructures have gained increasing importance. Over time, these developments may strengthen European reverse logistics networks and improve the efficiency of regional material recovery systems.

Regional material cycles may also provide benefits beyond logistics. Depending on the material, processing secondary raw materials often requires considerably less energy than extracting and refining primary raw materials. Consequently, circular economy approaches can contribute not only to raw material security, but also to improved energy efficiency and resource productivity.

Whether these benefits translate into measurable economic advantages, however, will continue to depend on the specific product, return volumes, available service networks, and the maturity of regional recycling and remanufacturing infrastructures.

7.3 Higher Labour Costs May Limit Economic Viability

Compared with many Asian manufacturing locations, Europe continues to have relatively high labour costs. This structural difference cannot be fully compensated through automation or organisational improvements alone.

The economic viability of remanufacturing and material recovery therefore depends on many additional factors. Besides labour costs, material value, transportation costs, energy prices, commodity prices, automation levels, product lifetime, maintenance cycles, and regulatory requirements all influence the overall business case.

Products containing high-value materials or precious metals, combined with long service lives and regular maintenance intervals, generally offer significantly greater economic potential than short-life consumer electronics with comparatively low material value.

For this reason, the economic viability of circular business models cannot be assessed universally. It must always be evaluated on a product-specific basis.

7.4 Reused Assemblies Require Robust Quality Assurance

This challenge extends beyond commercial considerations and includes important technical, regulatory, and safety-related aspects.

Reused assemblies and components naturally differ from newly manufactured parts. Their continued use therefore requires appropriate inspection, qualification, testing, documentation, and quality assurance procedures.

The international standard **IEC 62309** already provides an established methodological framework for products incorporating reused components. It defines approaches for assessing remaining service life, qualification testing, documentation requirements, and quality assurance procedures. Critical ageing components—such as electrolytic capacitors—are replaced regardless of their external condition, while all remaining components are evaluated according to defined technical criteria. Although this does not create complete equivalence with new products, it does provide a transparent, documented, and technically verifiable quality standard. [23]

Looking ahead, digital product information—particularly through the **Digital Product Passport (DPP)**—could further improve traceability by documenting materials, repairs, maintenance history, and component replacements throughout a product's life cycle. This could significantly enhance future qualification and verification processes for remanufactured electronic assemblies.

7.5 Europe Still Lacks Sufficient PCB and Material Manufacturing Capacity

This objection is equally valid. Even if substantially larger quantities of secondary raw materials become available within Europe, this does not automatically mean they can also be processed entirely within Europe. Manufacturing capacities remain limited in several strategically important

segments of the electronics value chain, including printed circuit boards, laminates, copper foils, specialty chemicals, and other intermediate materials.

For this reason, this White Paper does not present the circular economy as a short-term solution. Rather, it should be viewed as one possible catalyst within a broader long-term industrial strategy.

If Europe's industrial policy objectives are consistently implemented while simultaneously expanding manufacturing capabilities across the electronics value chain, greater availability of secondary raw materials could increasingly support regional value creation.

The circular economy alone will not restore Europe's manufacturing competitiveness. However, it has the potential to become one important pillar of a broader European strategy aimed at strengthening technological sovereignty, supply chain resilience, and sustainable electronics manufacturing.

7.6 Circularity Begins with Product Design

One important aspect is frequently overlooked in discussions about circular economy: the success of remanufacturing and high-quality material recovery is largely determined during product development.

Electronic products designed for modularity, easy disassembly, repairability, and component replacement can generally be remanufactured and recycled far more efficiently than products that are permanently bonded or difficult to separate. Consequently, **Design for Circularity** becomes a fundamental prerequisite for economically viable circular business models.

This also broadens the role of OEMs. While EMS providers contribute manufacturing expertise, industrialisation know-how, and process capabilities, many of the key decisions influencing future material recovery, resource efficiency, repairability, and recyclability are made during product development. Closer collaboration between OEM development teams and EMS providers therefore has the potential to significantly improve the long-term circularity and sustainability of electronic products.

8. Limitations of This Strategic Consideration

This Strategic White Paper deliberately adopts a forward-looking strategic perspective. It brings together several developments in European industrial policy, circular economy, and electronics manufacturing to explore how they could potentially reinforce one another. While each of the individual developments discussed is supported by existing evidence, their combined interaction has not yet been comprehensively examined in the available scientific literature.

For this reason, several limitations should be explicitly acknowledged.

- **The strategic logic presented in this White Paper is not an empirically verified cause-and-effect model.** To the best of our knowledge, no scientific study currently demonstrates a direct relationship between a stronger European circular economy and an increase in manufacturing sourcing decisions in favour of European electronics production.

- **The concept introduced in Chapter 6 regarding the inclusion of future material recovery and residual value within Total Cost of Ownership (TCO) assessments represents an original strategic consideration developed by EMS Strategy Group.** During the research for this White Paper, no comparable valuation model or academic publication addressing this relationship could be identified.
- **Several European policy initiatives discussed in this paper remain under development.** Their final scope, regulatory design, implementation timeline, and practical impact may therefore evolve as the legislative process continues.
- **The long-term interaction between industrial policy measures and international trade regulations remains uncertain.** It is therefore not yet possible to assess how European procurement rules, funding programmes, or local value creation requirements will ultimately develop.
- **A stronger circular economy alone will not fundamentally restore Europe's industrial competitiveness.** Circular economy initiatives can only unfold their full potential if they are accompanied by continued investment in manufacturing capacity, printed circuit board production, advanced materials, recycling infrastructure, and the broader European electronics value chain.
- **Europe's current industrial processing capacities remain limited in several strategic segments.** Even if substantially larger quantities of secondary raw materials become available, additional investments in manufacturing, material processing, and industrial infrastructure will be required before a greater proportion of these materials can be transformed into European value creation.

These limitations do not weaken the central argument of this White Paper. Rather, they clarify its intended purpose. The strategic logic presented here should not be interpreted as a prediction of future market developments, but as a framework for discussion that explores how industrial policy, circular economy, critical raw materials, manufacturing capabilities, and strategic sourcing decisions could interact over the long term to strengthen Europe's electronics industry.

9. Conclusion: A Strategic Perspective for Europe's Electronics Industry

This Strategic White Paper does not claim to establish a new economic relationship or present definitive scientific proof. Instead, it brings together developments that have largely been considered separately—European industrial policy, critical raw materials, circular economy, product development, manufacturing sourcing, and Total Cost of Ownership—and asks whether their interaction could create an additional long-term competitive advantage for Europe's electronics industry.

The starting point is clear. Over recent decades, Europe has experienced a substantial decline in manufacturing capacity across key segments of the electronics value chain. At the same time, the European Union is pursuing increasingly ambitious policies aimed at securing critical raw materials, strengthening industrial value creation within Europe, expanding domestic manufacturing capabilities, and accelerating the transition towards a circular economy. Parallel developments—including sustainability requirements, geopolitical uncertainty, supply chain disruptions, and growing demands for resilience—are already changing the criteria by which manufacturing partners are evaluated.

The central conclusion of this White Paper is therefore **not** that the circular economy alone will restore Europe's industrial competitiveness. Rather, it suggests that the circular economy could become one important building block within a broader industrial strategy—working alongside investment, innovation, industrial policy, resilient supply chains, and expanded European manufacturing capacity to strengthen Europe's position in global electronics manufacturing.

A key prerequisite for this development is recognising that circularity does not begin at the end of a product's life. It begins during product development. **Design for Circularity**, the **Digital Product Passport (DPP)**, and the growing integration of remanufacturing into industrial value chains all have the potential to influence how electronic products are designed, manufactured, maintained, recovered, and ultimately returned to productive use. In this sense, future competitiveness may increasingly depend on considering the entire product life cycle rather than focusing solely on manufacturing costs.

Against this background, this White Paper deliberately raises the question of whether future **Total Cost of Ownership (TCO)** methodologies should evolve. While end-of-life activities have traditionally been viewed almost exclusively as cost factors, improved digital product information, more mature reverse logistics systems, stronger remanufacturing capabilities, and increasingly integrated European value chains could eventually make it possible to incorporate the future economic value of recovered materials, components, and assemblies into procurement decisions. Whether such valuation approaches become established in practice remains uncertain and will require both practical experience and further academic research.

The analysis also demonstrates that the circular economy alone cannot overcome Europe's structural industrial challenges. Long-term competitiveness will continue to depend on sustained investment in manufacturing capacity, advanced technologies, innovation, skilled labour, competitive energy supplies, and stable industrial policy frameworks. Circular economy initiatives cannot replace these foundations—but they may significantly strengthen them.

Ultimately, the extent to which this strategic perspective becomes reality will depend on political decisions, industrial investment, technological progress, regulatory developments, and the willingness of companies to view product development, manufacturing, remanufacturing, recycling, and material recovery as interconnected elements of a single industrial value chain.

For this reason, this White Paper should not be understood as a forecast. Rather, it is intended as an invitation to reconsider established assumptions and to explore whether Europe's electronics industry could strengthen its long-term competitiveness by connecting industrial policy, circular economy, manufacturing, and strategic sourcing more closely than has been the case in the past.

If this discussion contributes to broadening the perspective on future sourcing decisions, industrial value creation, and the strategic role of circular economy within Europe's electronics industry, it will have achieved its objective.

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About the author

Dirk Kaussen is Founder and Managing Director of EMS Strategy Group. With around 40 years of experience in the electronics industry — including founding and managing his own electronics manufacturing company in Germany — he brings deep expertise in manufacturing processes, EMS partner selection, supply chain stability, relocation projects, and risk management. His approach combines practical solutions with a direct connection to industrial reality.

About the EMS Strategy Group

EMS Strategy Group supports industrial enterprises in the strategic advancement and optimization of their electronics manufacturing operations – from high-level planning to operational execution. Our core expertise lies in the strategic relocation of manufacturing volumes to European EMS providers, the establishment of new production capacities, and the expansion of existing manufacturing structures.

Furthermore, we design resilient supply chain frameworks, conduct comprehensive risk assessments, and guide dual-sourcing strategies to secure and fortify supply chains. Upon request, we manage projects closely until a successful serial production ramp-up is achieved.

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