T&D europe

The European Association of the Electricity Transmission and Distribution Equipment and Services Industry

Circularity in the T&D Industry

White paper

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1. Why do we talk about circularity?

Over the last 50 years, global material usage has almost quadrupled and it is expected to double again by 2050. Yet more than 90% of all materials extracted and used worldwide are ultimately wasted.[1] The situation is worsening year-on-year, as the share of secondary materials in total global material consumption decreased from 9.1% in 2018[2] to 7.2% in 2023[3], driven by rising material extraction and consumption. The environmental consequences are severe as studies show that more than 90% of biodiversity loss is due to the extraction and processing of natural resources[4] and 70% of all global greenhouse gas emissions are related to material handling and use.[5]

To operate within planetary boundaries and to preserve Earth's habitability, a fundamental shift in production and consumption patterns is essential, otherwise we could see resource use increase by 60 per cent from 2020 levels by 2060.[6] Only through

[1] Circular Economy, *Circularity Gap Report (CGR) 2022*, 2022, available online.
[2] Circular Economy, *Circularity Gap Report (CGR) 2022*, 2022, available online.
[3] Circular Economy, *Circularity Gap Report (CGR) 2024*, 2024, p. 8, available online.
[4] European Commission, "Circular Economy", available online.
[5] Circular Economy, *Circularity Gap Report (CGR) 2022*, 2022, available online.
[6] United Nations Environment Programme (UNEP) and International Resource Panel (IRP), *Global Resources Outlook 2024: Bend the Trend – Pathways to a Liveable Planet as Resource Use Spikes*, 2024, available online.

such a change can we meaningfully reduce resource consumption, mitigate resource scarcity, and lower environmental impacts, particularly greenhouse gas emissions.

The EU is expected to release the EU Circular Economy Act (CEA) in Q4 2026. The Act will allegedly cover circularity measures focused on the raw materials used in the T&D industry. We welcome this approach, but measures shall be reasonably achievable by the industry within the expected timeframe and should create a level playing field for all market participants and provide a clear policy signal for companies to integrate circularity into product design, manufacturing, and business models. Furthermore, the Competitiveness Compass, published by the European Commission in February 2025, identifies the circular economy as a key driver of EU competitiveness. The Competitiveness Compass notes that circular business models and remanufacturing activities already generate significant economic value, with the market estimated at €31 billion today and projected to reach €100 billion by 2030.

This growth demonstrates the substantial value-creation potential of circularity for the European economy. We hope that the forthcoming EU Circular Economy Act further signals Europe's commitment to unlocking this opportunity and accelerating the transition to a more circular economic model.

2. T&D Industry and Circularity

The T&D industry is not exempt from these challenges, as it plays a fundamental role in the energy transition and the sustainable development of power systems, and this raises the question of how to manage resources during a period of strong growth in the T&D sector. At the same time, T&D stakeholders are increasingly demanding consistent approaches to measure and improve circular performance and carbon footprint across the equipment lifecycle.

Compared with many industrial sectors, the T&D industry already benefits from several intrinsic circular characteristics. T&D equipment is mostly composed of a high proportion of recyclable materials, particularly metals, and is designed for long operational lifetimes (up to 40 years as per IEC 62271-320), which can often be extended through maintenance,

repair, refurbishment, and modernisation activities. Furthermore, circularity in the sector includes design choices related to durability, maintainability, repairability, and recyclability.

Despite these strengths, growing stakeholder expectations and the increasing use of circularity-related ESG metrics have highlighted the **need for greater clarity, harmonisation, and sector-specific guidance** on how circularity should be assessed and enhanced across the T&D value chain. While the industry is already well positioned compared with many other sectors, stakeholders continue to seek practical approaches to further improve circular performance.

This white paper aims to address these questions from T&D Europe's perspective. It provides guidance for advancing circularity within the T&D sector and calls for specific and sustained support from European institutions, including effective regulation and enhanced collaboration among all T&D stakeholders to enable a successful circular transition.

We will explore circularity across the different stages of the T&D equipment lifecycle through:

- the presentation of a general circularity framework to support the discussion;
- a chapter on upstream circularity covering design, procurement, and manufacturing aspects;
- a chapter on downstream circularity, addressing equipment operation, lifetime extension, end-of-life management, and value recovery processes.

The paper will conclude with key findings and recommendations for advancing circularity within the T&D sector.

3. General framework

There are many different frameworks that have been developed for circularity. For instance, the following frameworks[7], although developed for generic purposes, could also be applied to circularity strategies for T&D equipment:

1. Closing the loop (circular performance)
   a. Design for separability allowing recovery for remanufacture, reuse, or recycling;
   b. Through the use of recycled materials;
   c. Regeneration or re-refining of insulating materials instead of energy recovery.
2. Narrowing and slowing the loop (resource efficiency)
   a. Through existing life extension services with a quality commitment;
   b. Optimum material use in design with regard to environmental, technical, social and economic aspects.
3. Value the loop of circularity
   a. Through financial metrics on circular offerings, e.g. circular revenue;
   b. Through social and environmental benefits.
4. Impact of the loop
   a. With monitoring and assessing the environmental impact reduction of the circular offering (e.g. through LCA).

For the purpose of this paper, upstream circularity covers design, procurement and manufacturing, while downstream circularity covers operation, lifetime extension and end-of-life management. Narrowing, slowing and closing the loop may apply across these different lifecycle stages, while their economic value, environmental and social impacts can be assessed to evaluate the outcomes of these strategies.

[7] World Business Council for Sustainable Development (WBCSD), *Global Circularity Protocol for Business*, 2025, available online.

4. Upstream Circularity

Upstream circularity begins at the design stage, where decisions regarding product architecture, material selection and functional performance may determine up to 80% of the equipment's environmental and circular performance[8]. Topics such as durability, reliability, maintainability, repairability, upgradeability, and end-of-life recovery must be considered from the earliest stages of product development. The T&D Industry, however, is very different from the consumer products, and these requirements have already been considered and integrated, when feasible, in product design for decades.

Additionally, aligned customer requirements and market expectations play an important role in guiding and limiting these design decisions and could act as levers to support the transition from the current linear model to a circular model.

This approach is increasingly supported by European regulation through the Ecodesign for Sustainable Products Regulation (ESPR) and the Joint Research Centre's latest communication on the future Digital Products Passport (DPP). Article 5 of this regulation identifies a broad range of product requirements that directly influence circularity including durability, reliability, reusability, upgradability, repairability, maintenance and refurbishment, energy, water and resource use and efficiency, recycled content, remanufacturing, recyclability, recovery of materials and the expected generation of waste.

Those circularity requirements are usually interconnected. For instance, material selection and design for separability represent one of the most important circularity levers in T&D equipment. Design choices regarding materials influence both lifetime extension and end-of-life recovery and therefore determine the ability to repair, refurbish, disassemble, and recycle products. However, circularity objectives must be balanced with critical technical requirements, as well as with the overall lifecycle environmental performance of the product, including energy efficiency and operational losses.

Let's now review the specific challenges T&D equipment manufacturers face.

[8] Ellen MacArthur Foundation, "An introduction to circular design", 7 June 2022, available online.

a. Assessing Circularity

Beyond policy drivers, stakeholders in the T&D industry are increasingly seeking to measure environmental impact and circularity, whereas previously decarbonisation played a more prominent role. Although significant work has been done on international standards dealing with material efficiency in the circular economy (e.g. IEC 60050-193), many stakeholders are trying to define their own Key Performance Indicators (KPIs). In this fragmented and non-standardised circularity KPI landscape, we see a risk of overloading suppliers with individual customer sustainability requests. Furthermore, the rush to define KPIs could lead to defining indicators that prioritise results that **contradict other environmental metrics and ignore trade-offs**.

It is therefore important to understand that the levers of circularity could differ depending on the type of equipment in this industry. Furthermore, this situation is exacerbated across the supply chain as different industries (primary manufacturers, Original Equipment Manufacturers (OEMs), recyclers...) could require different KPIs. The lack of standardisation of secondary material manufacturing processes and technologies could also further complicate the measurement and understanding of industrial realities.

Therefore, we urge the different industry associations across the value chain to work on the **standardisation** of both secondary material and circular product manufacturing methodologies and KPI definitions and encourage collaboration to agree on a common methodology and set of parameters that are industry-specific rather than country or customer specific to further educate stakeholders on the complexity of the topic.

While assessing upstream circularity remains challenging, particularly when evaluating recycled content and material recovery performance, some standards are gaining weight on the evaluation requirements and shall be taken into consideration. Life Cycle Assessment (LCA), Environmental Product Declarations (EPDs) and the EN 455xx standards provide established methodologies for product environmental evaluation, but significant uncertainties remain due to variations in recycling processes, end-of-life treatment routes and secondary material production technologies.

Manufacturers also face practical challenges in tracking the actual **recycled content** of materials. For **metals**, recycled content can vary significantly between suppliers and production batches, while transparency across multiple supply chain tiers is often limited.

The amount of recycled content will also depend on the availability of recycled materials on the market, and whether the growth of recycled materials' collection correlates with the growth of materials' production, which is not always the case, e.g. in phases of technology transition (as is currently the case) or strong industrial growth, and would lead to a decrease of average recycled content. Depending on the process used (e.g. steel produced with Basic Oxygen Furnace vs. Electric Arc Furnace), you will also have limitations on the maximum possible recycled content. Generally speaking, the maximum possible collection of recyclable materials should be encouraged.

Similar challenges exist for **plastics, oils and electronic components**, where technical performance requirements, limited recycling infrastructure, absence of standardised claims and supply chain constraints can restrict the effective use of recycled or circular materials. Traceable content declarations would require a dynamic chain of custody models that do not exist yet. Consequently, circularity assessments should focus not only on recycled content but also on broader indicators such as durability, secondary material sourcing, reparability, and material recoverability.

T&D Europe therefore proposes not to include recycled content percentage as a KPI until robust and harmonised methodologies, reliable data and proportionate traceability mechanisms are available. For transparency purposes, we also encourage stakeholders to **accept mass balanced methodologies** by material as defined in EN 45557 (recycled content) and agree on standardised requirements.

b. Circularity of materials

Since most T&D equipment consists predominantly of **metals,** the sector benefits from a high theoretical material recovery potential. Nevertheless, achieving this potential depends on the quality and efficiency of the entire end-of-life value chain, including collection systems, sorting processes, recycling technologies, and secondary material

production. For example, the amount of scrap deliveries to metal mills will vary during the year, leading to different levels of recycled content by batch. Different metal suppliers may use recycled metals in different manufactured products (for supply chain resilience purposes) leading to an inevitable lack of transparency on the exact level of recycled content in such part. Instead of values for individual deliveries, an average recycled content for each type of material should be used.

For **plastics,** there is a wide range of materials used for different high mechanical and electrical performance requirements. In some cases (e.g. thermoplastics), the material performance could be compromised by using recycled materials, as they may present a lower performance or be unsuitable for the application needed. Other plastics, such as thermosets (e.g. epoxy), have no direct recycling technology and currently the only possibility to reuse is energy recovery or creation of monomers through polymer chemical recycling. The lack of plastics recycling facilities also makes industrial level recycling difficult due to costs and unavailability. Additionally, the materials we are recycling now were produced 40 years ago, while market and regulatory requirements for these substances have continuously evolved.

For the various **oils** used in the T&D equipment, there are currently no standardised requirements for the claiming of recycled content, leading to potential abuse of the "recycled" wording. High-percentage recycled oils exist on the market and are a viable solution, both technically and financially.

For **electronics** such as Printed Circuit Boards, there is a very low availability of more sustainable electronics. As the T&D Industry is not a major electronic industry, the scope for action to request more circular solutions is limited. In 2022 in Europe, 7.4 million tonnes of electronic goods were discarded, including significant quantities of Critical Raw Materials such as rare earth minerals, gold and copper.[9]

The European Union should provide appropriate policy and economic support and investment mechanisms to encourage R&D and improvements in scrap and waste

[9] International Telecommunication Union (ITU) and United Nations Institute for Training and Research (UNITAR), *Global E-waste Monitor 2024*, 2024, available online.

collection technologies, with particular attention to critical raw materials such as copper. This approach can create and secure stronger demand for scrap within the EU.

5. Downstream Circularity

This chapter focuses on downstream circularity, which addresses circularity during operational life and the end-of-life of the product. The extension of the operational lifetime of equipment, thereby reducing unnecessary manufacturing of new equipment is a powerful lever for circularity, as the greenest resource is the one you don't use. Nevertheless, this chapter will also explore the strategies to recover resources at the end of the product life, to ensure that as many resources as possible remain within a circular loop. We also note that stakeholders need a holistic assessment of the benefits and disadvantages of extending old equipment in the grid, as other sustainability impacts of older technologies, such as higher F-gas leakage and lower energy efficiency might offset the benefits of extending the life of this equipment.

a. Life extension

As per the Ecodesign for Sustainable Products Regulation, **durability** is the ability of a product to maintain over time its functions and performance under specified conditions of use, maintenance and repair. Asset Life Extension plays a critical role in enhancing product durability. In a truly circular economy, end-of-life should be postponed wherever possible, keeping products, components and materials in use at their highest value.

Through the proper use of **performance monitoring, predictive maintenance** (in addition to preventive maintenance) and **repair,** end users could maximise equipment reliability for life extension.

A large proportion of the installed equipment base could remain in service under quality control of manufacturers through **refurbishment, retrofits, repair and other life-extension strategies**. These strategies would also deliver environmental and economic benefits. For example, avoiding the premature replacement of equipment can reduce greenhouse gas emissions associated with manufacturing new products, while also

minimising downtime, shortening delivery times and lowering investment costs for end users.

To support these benefits, utilities and industry associations should encourage the digitalisation of equipment, enabling end-users to continuously monitor equipment, conduct predictive maintenance, and make informed end-of-life decisions. Such monitoring requires end-users to have an appropriate methodology to ensure that the data collected are properly stored and proactively used. National authorities should also promote circular products and services to support the manufacturers that already offer solutions.

b. End of life

As a final strategy, **End-of-Life Care** for the product ensures that the existing resources will be recovered, recycled and returned to the productive cycle. In many cases, products (e.g. medium-voltage switchgear) are directly shredded without disassembly, meaning that some Ecodesign criteria may not be relevant from an industrial perspective.

Given the intrinsic recovery value of material in T&D equipment, when disposal is the only available option, **recycling** should be the preferred method. While metal recycling is a mature industry, recycling of other materials (e.g. high-performance plastics or electronics) remains underdeveloped. As a result, many resources are either incinerated or end up in landfills. To improve resource recovery, T&D Europe encourages collaboration with utilities and national associations to develop standardised **product-specific end-of-life guidance** based on value recovery principles and environmental impacts.

Europe is currently the world's largest scrap steel exporter, with over 16 million tonnes exported in 2024,[10] while remaining the largest steel importer in the world with a record 27.4 million tons in 2025[11]. **Increasing the use of recycled metals** within Europe will require additional Electric Arc Furnace (EAF) capacity, which can also incorporate significantly higher levels of recycled content than conventional steelmaking routes.

[10] European Steel Association (EUROFER), European Steel in Figures 2025, 2025, available online.
[11] European Steel Association (EUROFER), European Steel in Figures 2025, 2025, available online.

While mechanisms such as the Carbon Border Adjustment Mechanism (CBAM) contribute to a level playing field, they are unlikely on their own to stimulate the scale of investment needed. T&D Europe therefore encourages the EU to introduce measures and incentives that support the production of low-carbon and recycled-content metals within Europe, strengthening both circularity and supply-chain resilience.

Current default values for material recycled content and recovery rate are registered by the European Commission and presented in standards such as EN 50693 for reference when no specific information about the end-of-life treatment of materials is available. An example is shown in the following table. These values could be improved with an increase in capabilities and research in recycling technologies.

We call on the European Commission to accelerate investment in next-generation recycling technologies and industrial recycling facilities across Europe. Expanding recycling capabilities, especially waste streams containing Critical Raw Materials (CRMs), is a strategic priority to strengthen circularity, improve resource security, and enhance the competitiveness of European industry. Such measures would help standardise recycling practices, improve recovery rates, and increase the availability of secondary raw materials.

Furthermore, the EU should create a more enabling framework for the transformation of waste into secondary raw materials, while maintaining high standards for quality, safety, and traceability of materials. Unnecessary regulatory and administrative barriers should be reduced to facilitate the uptake of secondary materials by the industry, and the development of harmonised traceability requirements throughout the value chain should be promoted, while existing methodologies such as mass balancing for tracking recycled content should be allowed.

Strengthening the ability of European raw material suppliers to recover and reintroduce materials into the value chain will improve supply chain resilience, reduce reliance on imported primary resources, and support the development of a robust circular economy.

6. Main circularity levers

The EU Circular Economy Act is expected to provide an overarching framework for embedding circular economy principles across the European economy. These principles will then be translated into product-specific requirements through instruments such as the Ecodesign for Sustainable Products Regulation, which will replace the existing Ecodesign Directive and extend its scope beyond energy efficiency. Together, these initiatives send a clear policy signal to equipment manufacturers to integrate circularity considerations into product design, manufacturing processes, and business models.

Other legislative initiatives are already encouraging the use of low-carbon materials through public procurement requirements (such as steel or aluminium). T&D Europe also urges the European Commission to ensure consistency between the regulations affecting circularity and industrial development, such as the Circular Economy Act, the Ecodesign for Sustainable Products Regulation, the Critical Raw Materials Act, public procurement requirements and other relevant legislation so that circularity requirements reinforce each other rather than create overlapping or conflicting obligations.

For T&D products, this policy context is particularly relevant due to the complexity of supply chains, the long service life of infrastructure assets, and the growing demand for critical raw materials. These factors, combined with increasing concerns about security of supply, have further highlighted the role that circularity can play in strengthening industrial resilience. In this regard, the Critical Raw Materials Act explicitly recognises the contribution of reuse, recycling, and recovery to securing the supply of strategically important materials.

Beyond policy drivers, stakeholders across the value chain are increasingly demanding stronger sustainability credentials from suppliers that work ahead of standardisation of circularity KPIs. However, KPIs should be adapted to the characteristics of different T&D product groups and applications, while remaining based on harmonised and consistent methodologies across the value chain. As T&D Europe, we are willing to support the definition of such KPIs, using our domain expertise.

Increasing circularity has the potential to deliver significant sustainability benefits across the T&D sector, including reduced demand for virgin raw materials, lower lifecycle greenhouse gas emissions, and improved resilience of critical supply chains. For T&D equipment, this means prioritising strategies such as refurbishment, repair and lifetime extension, while ensuring appropriate material recovery when further use is no longer feasible. Given the long service lives and safety-critical nature of T&D assets, however, the sustainability impact of circularity is closely linked to maintaining performance, reliability, and safety over time, rather than focusing solely on material reduction or recycling rates.

However, in addition to regulatory requirements, policymakers should support **EU suppliers developing circular products and services**, while also encouraging public stakeholders to reward suppliers and actively implement circularity initiatives. Value sharing initiatives should also be encouraged as actions benefit not only customers or suppliers but general economy and society. Value-sharing mechanisms and financial incentives would encourage stakeholders to adopt more circular practices.

7. Key Takeaways & recommendations

- Regulatory requirements should be aligned with **existing international standards** (taking into account the specific boundaries of T&D equipment), including the forthcoming IEC 60050-193 for circular economy, the EN 4555x series for assessing circularity and the broader ISO 590xx family for business circular economy standards.
- While metal **recycling** shows some maturity, the recycling of other materials, such as plastics, electronics and fluorinated gases (SF6 and alternatives), will require further support and investment to develop economically sustainable infrastructure that supports the circular economy.
- Given the strategic importance of **metals** (e.g. steel, copper and aluminium), as well as electronics, for the T&D sector, we encourage the European Commission to engage in discussions with key users of these metals, such as T&D Europe, to ensure that the requirements for the T&D industry remain technically feasible and economically realistic, while maintaining the functionality and safety of the equipment. T&D Europe stands ready to support the Commission in that regard.
- T&D equipment manufacturers continue to bring increasingly circular products to market. End users should be encouraged to assess replacement decisions on a case-by-case basis, considering the overall lifecycle performance of the equipment, including efficiency, reliability, safety and environmental impacts.