

THE CONTRIBUTION OF CIRCULAR ECONOMY BEST PRACTICES FOR ELECTRICAL AND ELECTRONIC EQUIPMENT TO THE SUSTAINABLE DEVELOPMENT GOALS

Marco La Monica¹, Tiziana Beltrani¹, Francesca Ceruti², Francesca Ferrero³
Mariarita Paciolla³ and Giacomo Seravalli³

¹Laboratory Resources Valorization (RISE), Department for Sustainability (SSPT), ENEA,
Via Anguillarese, 301, 00123 Rome, Italy

²Department of Economics and Management (DEM), University of Brescia, Contrada S.
Chiara 50, 25122 Brescia, Italy

³CDCA - Centro di Documentazione sui Conflitti Ambientali, Via Macerata 22/A, 00176
Rome, Italy

marco.lamonica@enea.it

The transition to the circular economy is revolutionizing existing business models. Companies have to initiate and implement a complex transformation process across the entire value chain, from the ecodesign stage to end-of-life management. In this new economic paradigm, the product design phase also involves consideration of the end of its life cycle, incorporating solutions to facilitate the replacement of parts to extend their useful life and paying attention to the materials used and the energy cost of production. The consumption phase involves innovative business models, such as consuming services rather than products, sharing products or infrastructure, and using digital platforms. The end-of-life management phase of a product focuses on resource utilization and adopts reuse, refurbishment or recycling solutions.

The key role of business in achieving a sustainable model of economic development is also recognized in the Sustainable Development Goals (SDGs) proposed by the United Nations in 2015 to promote equitable and sustainable economic, social and environmental development by 2030. Among the 17 goals, there is a clear emphasis on the need to adopt new sustainable business models to address challenges such as poverty, food insecurity, climate change, and inequality. These objectives prompt businesses to reevaluate their methodologies and formulate strategies that embed sustainability principles throughout their operations, spanning the entire spectrum from supply chain management to production, distribution, and waste management. The adoption of new sustainable business models not only aids in tackling urgent global challenges but also opens avenues for innovation, expansion, and enduring profitability. In their research titled "The relevance of circular economy practices to the Sustainable Development Goals," Patrick Schroeder et al. conducted a comprehensive mapping exercise encompassing the 17 SDGs and 169 associated targets. The study illuminated that the most robust relationships and synergies between circular economy practices and SDG targets are evident in SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG12 (Responsible Consumption and Production), and SDG 15 (Life on Land). These specific SDGs demonstrate high scores for both direct and indirect contributions.

Circular examples can come from several sectors closely related to the SDGs, such as agribusiness, manufacturing, and the built environment, which are included along with cross-sectoral themes such as consumer goods or plastics, but also from less directly related sectors. Among these less directly related sectors, Electrical and Electronic Equipment (EEE) has to be mentioned because it has revolutionized society nowadays by increasing living standards and creating new communication methods. The widespread and global use of EEE has become a growing trend due to its exclusive

elements and the linkage with the critical raw materials (CRMs). Moreover, EEE contains precious metals and various substances whose extraction requires complex and expensive processing. Some materials are also included in the category of raw materials specified by the European Commission as critical (critical raw materials - CRMs). Given that the supply of CRMs plays a pivotal role in the European economy, as also highlighted by the Critical Raw Materials Act, the proliferation of electronic devices turns cities into veritable urban mines. Therefore, optimizing the EEE value chain in all its phases has become crucial in recent years.

Although the importance of these issues is globally recognized, to date, only a few examples of successful implementations are reported. Moreover, to the best authors' knowledge, only few scientific publications seem to be available on the contribution of the circular economy to the Sustainable Development Goals, especially in the EEE sector. The lack of this literature also means that the implementation of best practices in the EEE sector within companies is often not widely perceived by society, resulting in a knowledge gap between industry and the broader community. This gap contributes to the perception of the circular model as a distant goal rather than an achievable reality. Consequently, there is a pressing need to explore empirical cases shared by companies to gain insights into the key success factors, sustainable challenges, and the necessary steps toward achieving the paradigm shift from linear to circular models. Circular economy platforms have emerged as a response to this lack, providing a comprehensive overview of ongoing experiences. These platforms serve as invaluable tools for sharing and exchanging ideas, strategies, initiatives, knowledge, and challenges among diverse users. Their primary objective is to foster dialogue and facilitate cross-sectoral interactions, transcending boundaries of legal entities (including public entities, private companies, foundations, research institutes, and NGOs), countries of origin, and sectors. Through these platforms, stakeholders can collaborate and learn from each other's experiences, accelerating progress towards a more circular economy on a global scale.

For these reasons, the main research questions guiding the present work are:

1. What best practices (BPs) of transition to the circular economy exist at the European and Italian levels in the EEE sector?
2. How do the identified BPs contribute to the achievement of the SDGs?

This paper aims to present a comprehensive mapping, in the Italian and European context, of BPs related to the management of EEE and its waste (WEEE). The mapping of BPs is useful to delve into the characteristics, strengths and challenges encountered at all stages of the life cycle and by the economic actors involved. Aspects of BPs, such as their location and the SDGs they focus on, are also shown. In addition, a qualitative analysis illustrates the distribution of these aspects across specific product life cycle stages and economic sector. In order to provide a comparison between the European and Italian contexts, BPs are analyzed separately. Secondary sources of BPs concern the respective platforms, European (European Circular Economy Stakeholder Platform (ECESP)) and Italian (Italian Circular Economy Stakeholder Platform (ICESP)).

In more detail, ECESP, is the main platform for collecting best practices in the field of circular economy in Europe, established in 2017 as a joint initiative of the European Commission and the European Economic and Social Committee (EESC). ECESP has defined and published on its website the guidelines that identify the key criteria considered by the review group prior to including a best practice on the online database. ICESP was established in 2018 as the mirror Italian platform of the European ECESP. It was launched and coordinated by ENEA, the Italian National Agency for New Technologies, Energy, and Sustainable Economic Development. Given the close connection between

these two platforms, comparing the collected BPs was relatively straightforward. However, in some cases, information required some reworking to ensure uniformity and comparability.

Methodologically, concerning the Italian platform, all 214 best practices available as of April 27, 2023, underwent individual analysis. Out of these, only 15 were found to be related to electronic devices and were, therefore, the focus of the study for the Italian perspective. Meanwhile, the search for relevant best practices on the ECESP website utilized keywords such as "WEEE," "E-waste," and "Electronic devices". Following this search, a total of 43 best practices related to electronic devices were selected and compose the European BPs' database. For each best practice (BP), information such as the economic sector, the lifecycle phase it refers to, the geographical location, and the Sustainable Development Goals (SDGs) it focuses on has been associated. To ensure consistency between the two databases, a unified set of definitions for both databases has been constructed for lifecycle phases and sectors. Specifically, the identified lifecycle phases are: "Production", "Consumption", "Innovation and Investments", "Secondary Raw Materials", and "Waste Management". Regarding sectors, they include: "End-of-Life," "Education and Awareness," "Innovative Solutions," and "Services". In the data collection sheets for both platforms, information regarding the lifecycle phase and sector is mandatory, unlike the location of the BP. This information was derived, whenever possible, from the websites of the BPs themselves. Additionally, a new variable was created to analyze the contribution of the BPs to the SDGs of the 2030 Agenda. During the analysis of the best practices, particular attention was given to the correlation, whether explicit or implicit, with the sustainable development goals of the 2030 Agenda (SDGs).

Preliminary results indicate that the most commonly addressed lifecycle phase of a product by the best practices (BPs) was "Waste Management." Additionally, when examining economic sectors, the one with the highest number of BPs was "End-of-Life," encompassing activities like recycling, separate collection, and reconditioning. This underscores a critical aspect in analyzing the state-of-the-art of circular economy practices in the Electrical and Electronic Equipment (EEE) and Waste Electrical and Electronic Equipment (WEEE) supply chain – the predominant focus lies on the final phase of the product lifecycle. Specifically, when delving into the "Innovation and Investments" phase, which includes ecodesign, there are very few initiatives where it takes center stage. This indicates that the systemic approach, integrating an economic model that considers the product across all phases, is still far from full implementation. The absence of BPs in the "Innovative Solutions" sector of ICESP's database further underscores the necessity for increased emphasis on the design phase for electrical and electronic equipment in Italy. Conversely, an analysis of the "Services" sector highlights a concentration on the "Consumption" lifecycle phase. This signals the emergence of new business models not reliant on product ownership but rather on services, such as the sharing economy or eco-leasing. Furthermore, the alignment of BPs with the Sustainable Development Goals (SDGs) reflects a commitment to implementing sustainable production and consumption models (SDG 12), ensuring decent work and economic growth (SDG 8), and involving various stakeholders through online platforms and green initiatives (SDG 9).

This work, in addition to enriching the literature referring to sustainability in the EEE sector with particular reference to the circular economy and the SDGs provides valuable insights for managerial decision-making in the context of transitioning to a circular economy, particularly within the Electrical and Electronic Equipment (EEE) sector. Firstly, the study emphasizes the importance of circular economy platforms as valuable tools for sharing ideas, strategies, and challenges. Managers can leverage these platforms to stay informed about best practices, industry trends, and opportunities for collaboration. Engaging with these platforms can foster cross-sector interactions and help accelerate the adoption of the circular economy and, more broadly, contribute to the development of

a regional area. Secondly, the research underscores the scarcity of initiatives in the "Innovation and Investments" phase, specifically in eco-design. Recognizing this gap in current practices EEE industries should invest in innovation and eco-design processes. This involves designing products with consideration for their entire lifecycle, incorporating solutions for extending product life, and minimizing environmental impact. Lastly, the research establishes a strong correlation between circular economy practices in the EEE sector and specific SDGs. This information is useful for policy maker to align strategies with both global sustainability goals and regional development priorities, fostering a holistic approach to sustainable growth.

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