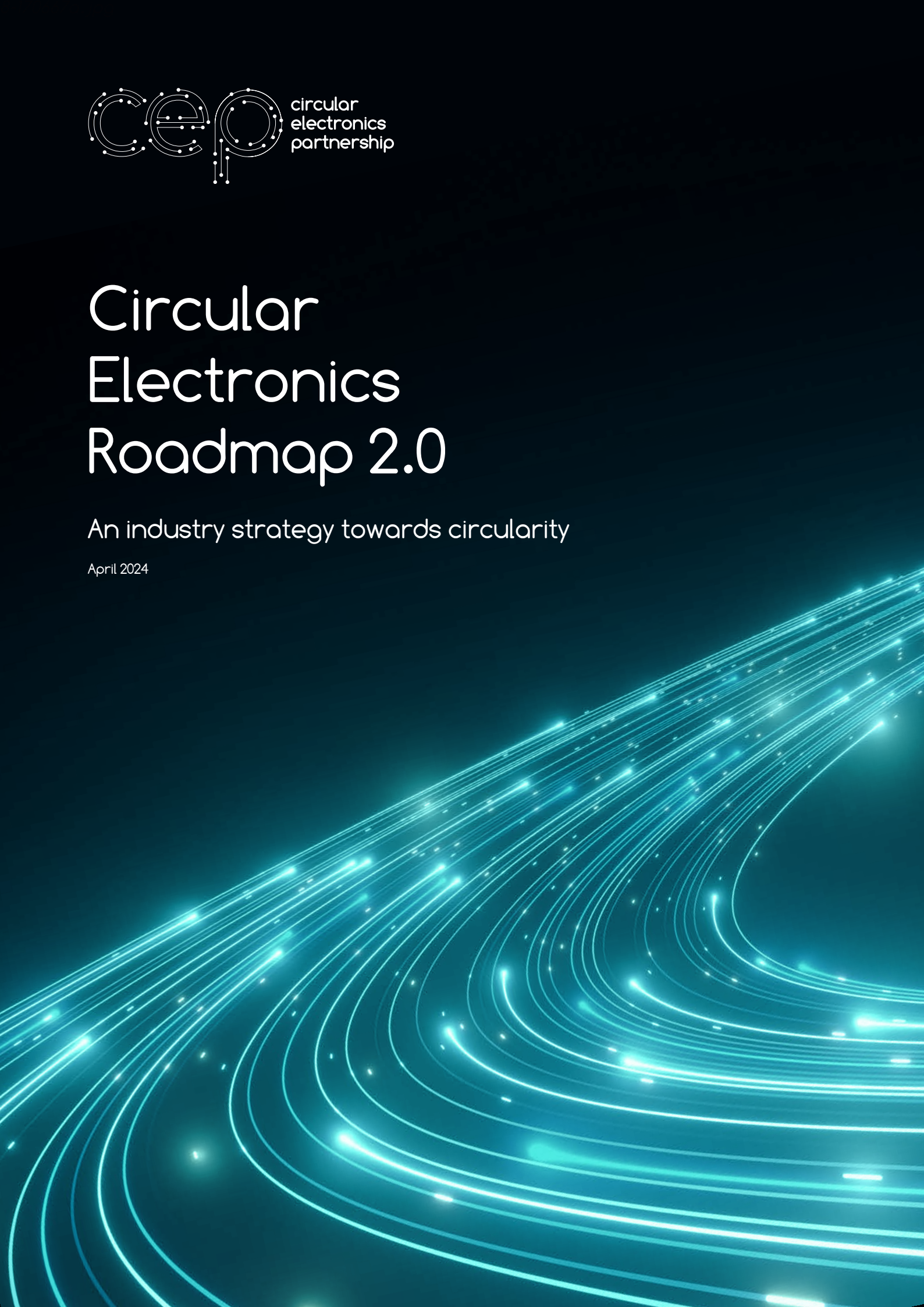
circular electronics partnership

Circular Electronics Roadmap 2.0

An industry strategy towards circularity

April 2024



Introducing the Circular Electronics Partnership

The Circular Electronics Partnership (CEP) is a coordination platform, established to bring together partners, industry members and the wider stakeholder network. It helps drive collective action on global initiatives for circular electronics, aligning CEP partners and members behind the vision of a circular electronics industry by 2030.[1]

This is the vision of an industry that maximizes the full value of components, products and materials, uses safe, fair labor, depends only on circular resources and generates economic value and more positive social and environmental impact.

This roadmap, originally published in 2021, acts as an industry strategy for realizing the circularity vision. It identifies what is needed across key stages of the electronics value chain to drive systemic transformation and invites the industry and its stakeholders to collaborate in addressing these actions.

Scope

Our vision for circular electronics includes all types of electronic and electrical equipment as defined by the EU Waste Electrical and Electronic Equipment (WEEE) Directive. This includes devices and equipment from six product categories: temperature exchange equipment, screens and monitors, lamps, large equipment, small equipment and small IT.[2]

Within this product scope, our activities follow the interest and expertise of our members. From a market perspective, circular electronics include business-to-consumer (B2C) and business-to-business (B2B) equipment, sold both in bulk and individually.

Partners

Global Electronics Council — Sustainability for a Connected Future

GeSI — Enabling Digital Sustainability

Responsible Business Alliance — Advancing Sustainability Globally

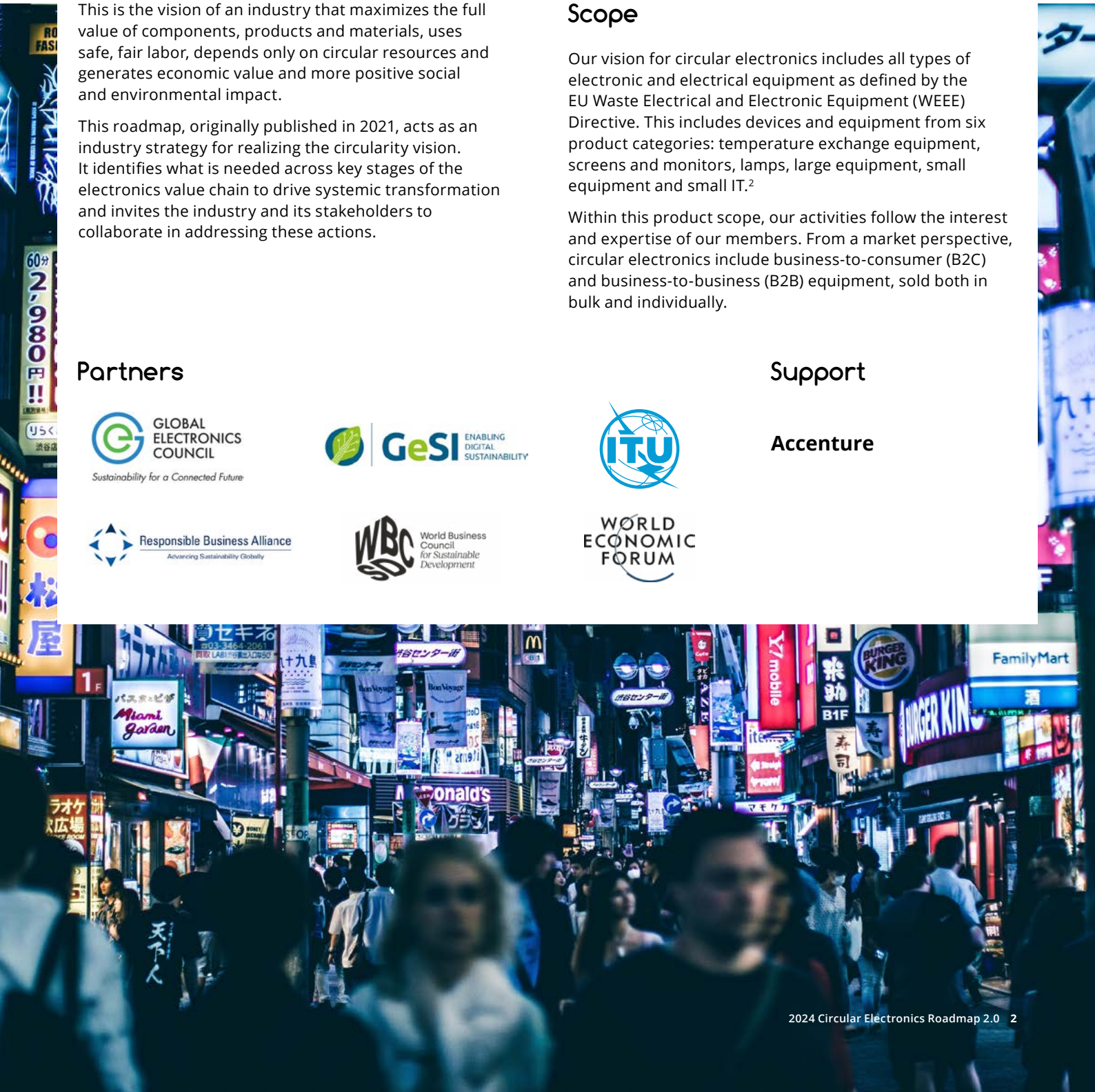
World Business Council for Sustainable Development

ITU

World Economic Forum

Support

Accenture



The need for action

The findings of the Global E-waste Monitor 2024[3] are clear; the growth of global e-waste generation is continuing to rise. In 2022, humankind generated 62 million tonnes of e-waste – a concerning rise from 53 million tonnes in 2019. Since publication of the original CEP Roadmap, the challenges associated with a historically linear industry have become increasingly pertinent.

- **While e-waste is one of the fastest-growing waste streams in the world,its disposal is not well managed**

  In 2020, e-waste represented 2% of solid waste streams, yet 70% of hazardous waste that ended up in landfill.[5] Demand for electronics persists due to several key driving forces, including greater affordability in developing economies, the integration of electronics into traditionally non-electronic goods and the propagation of electronics in everyday life. While the documented formal collection and recycling rate are also increasing, from 9.3 million tonnes in 2019 to 13.8 billion kg in 2022, this still only represents 22.3% of total e-waste.[6] Without corrective action, we can anticipate further acceleration of e-waste generation, greenhouse gas (GHG) emissions output and natural resource consumption.

- **Electronic goods represent a substantial proportion of an organization's carbon emissions**

  The use of electronic goods contributes to an organization's carbon footprint – both in terms of upstream and downstream emissions. The metal and mineral mining necessary for manufacturing devices, and the energy consumption related to using and disposing of them, all contribute towards the total CO_2 footprint.[7] Depending on the specific product, these emissions can make up 50% to 90% of total GHG emissions. Besides direct emissions from business operations (Scope 1 and Scope 2), reporting companies will also need to disclose indirect carbon emissions across their value chain[8] (Scope 3).[9]

  According to the 2024 Global E-Waste Monitor, e-waste management globally prevents 93 billion kg of CO_2-equivalent emissions in the form of refrigerants in temperature exchange equipment (41 billion kg) and through the lower greenhouse gas emissions obtained by recycling metals versus mining (52 billion kg).[10] Considering this equals over 40 million gasoline cars[11] off the road (all passenger cars in France in 2023),[12] this represents a substantial opportunity for further emissions reduction through increased e-waste management.

- **Supply chain interruptions and skyrocketing raw material prices challenge the stable supply of crucial raw materials for the electronics industry**

  In 2022, the value of metals in global e-waste was approximately USD $91 billion, mainly coming from iron, copper and gold.[13] This presents an economic opportunity for the electronics industry to invest in circular electronics. In particular, the COVID-19 pandemic highlighted the risks of linear supply chains, with spikes in demand exacerbating existing supply chain disruptions. One example is lithium, an essential component of battery production, which experienced a price increase of 500% between 2021 and 2022 due to supply shortages.[14] Demand for materials like lithium are only increasing due to their indispensable role in our global clean energy transition. A circular model for the industry would not only help mitigate such supply chain shortages, but also create economic opportunities.

- **Labor conditions and health impacts are key social issues associated with improper and informal e-waste recycling**

While soil and water contamination are known environmental issues, the global sanitary impacts of e-waste have still not been fully quantified. However, examples exist that clearly show the health impacts of improper and informal e-waste recycling. These include skin diseases, adverse effects on birth outcomes, cardiovascular effects and altered neurodevelopment or adverse learning outcomes.[15]

In India, for example, it is estimated that over 1 million people involved in informal, manual recycling are exposed to hazardous substances (heavy metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and brominated flame retardants (BFRs)) – presenting a real human health risk associated with informal electronics disposal.[16]

Overall, shifting to a circular economy for electronics can help address major challenges around climate, nature and human capital, as well as business continuity. Yet, despite efforts by individual stakeholders, progress seems to be reversing. In the past six years, according to the 2023 Circularity Gap Report,[17] global circularity decreased from 9.1% to 7.2%, with progress offset by rising material extraction and use. A radical transformation is needed – one in which all stakeholders need to collaborate beyond their organizational remits.

- **Fostering multi-lateral actions increases the global opportunity of circular electronics**

Despite their market power, individual electronics companies cannot act alone in transitioning towards responsible circularity. Given the global nature of the electronics supply chain, a "coalition of the willing" is needed across companies and value chain segments. The companies that demonstrate a willingness to act early and embrace circularity will ultimately be better positioned for tomorrow's market. Beyond the private sector, the collective transition towards a circular electronics industry will require partnerships with the public sector and civil society.

This updated roadmap was created to guide collective progress throughout the electronics value chain towards a more circular industry. The time for coordinated action, at scale, is now.

A roadmap towards circularity

In 2020, the CEP launched an extensive stakeholder engagement project to inform this first-of-its-kind roadmap. CEP mobilized the six founding partners, and more than 80 experts from 40 companies, industry associations and non-governmental organizations (NGOs). Following six months of collaboration, they identified the barriers, enablers and necessary interventions across six Pathways that would help drive progress in key stages of the electronics value chain.

Since then, the CEP has served as a coordination and collaboration platform, bringing together expertise and resources to remove industry-wide barriers for companies in their circular transition.

The CEP Roadmap is an invitation to industry peers and stakeholders to join forces and make collective progress. Combining the actions defined across the Pathways provides us with a comprehensive picture of what is needed to enable systemic transformation towards a more circular electronics industry.

Organizations that are already active in driving this shared agenda are welcome to contact the CEP on info@cep2030.org to explore collaboration on any of the topics in the roadmap. We look forward hearing from you!

Why this roadmap update?

Since 2020, the world and our understanding of circular electronics has evolved. To keep the CEP roadmap relevant, current members and founding partners initiated a holistic review in 2023. We collectively reviewed each of the Pathways and their respective 40 actions, adjusting them as needed. While these changes reflect the latest developments in the landscape of circular electronics, the revised roadmap maintains the level of ambition and insight gathered during development of the initial document.

What has changed in this edition?

This edition includes an update on overall trends, challenges, data points, policies and standards underpinning the industry transition to circularity. As a result of this, some actions have been refreshed, merged, removed or added. The newly included actions (Pathway 1.4, P3.3 and P0.1) reflect the need for circular transition tools within companies and the importance of assessing the Scope 3 GHG emission benefits of circular solutions. They also include our evolving understanding of data exchange and its role in enabling circularity, which is the roadmap's first cross-pathway action (0.1), showing the potential impact of data exchange on all six Pathways. As the circularity space matures further, it is possible other cross-pathway actions will be introduced.

With this update, a refined roadmap structure was also introduced (see below). This supports navigation of the actions and gives clearer guidance to the industry and its stakeholders on how they can contribute to the circular electronics vision. At the same time, the new structure provides a logical approach and framework for measuring progress.

The scope and overall content of this roadmap and its actions, including the six Pathways, have not changed. We are still working towards the ambitious timeline of 2030 but, on our current trajectory, it is unlikely we will achieve a full operational circular electronics sys tem by then. However, by 2030, most collective industry barriers to the circular transition should be addressed through the roadmap actions. This will pave the way for companies throughout the value chain to accelerate their circular transition.

Refined roadmap structure

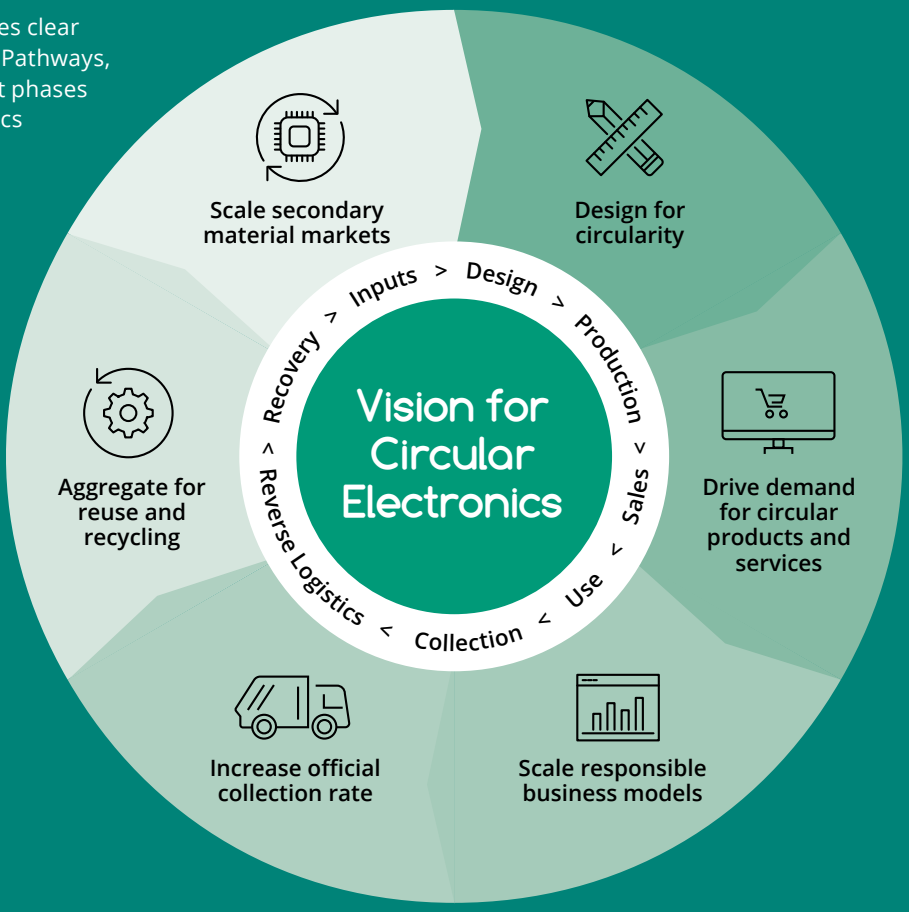
The new CEP Roadmap will help position the industry actions towards circular electronics in three dimensions:

- Pathways
- Action levels
- Prioritization of actions

Pathways

The CEP vision outlines clear objectives for the six Pathways, covering the different phases of a circular electronics value cycle.[18]

Figure 1. The six Pathways



Action levels

Three action levels define what context the action should be addressed in (see Figure 2):

- **Collective actions:** Interventions that require collaborative industry action; no company can develop a circular economy on its own. Action is needed on an industry level to define a common, consistent understanding of how circularity is discussed, organized, measured, reported and assured, etc. Collective progress will help individual companies accelerate their own transition.
- **Company actions:** Interventions for individual value chain players, i.e., companies; ultimately, industry transformation is driven by individual companies making the switch from linear to circular business. Individual company actions are calls for companies to continue making that shift, supported by the outcomes of collective actions and enabled by the wider stakeholder ask.
- **Wider stakeholder ask:** Interventions for governments, NGOs and research organizations. It is the view of CEP that businesses should not wait for regulation to come into effect before acting. Rather, the industry should pioneer and use its experience to help policymakers develop effective and productive policies. Front runners will have a competitive advantage over those companies that wait for regulation to be imposed upon them before acting. However, the asks in this section will help level the playing field and enable companies to transition faster and more effectively.

Determining these action levels helps us understand how to address the actions, as well as how to measure them. It is important to note that all stakeholders have a role to play in almost every action, regardless of the level. The action level should therefore not be understood as addressing a siloed audience.

Since all stakeholders play their own, but interdependent, role, the action levels have an equal priority to be addressed and reinforce each other in driving impact.

Prioritization and interdependencies of actions

The sequence of actions within a Pathway indicate each action's relationship to the others in that same Pathway. A logical order would be to start at the top and work down. However, experience teaches us this may not always be required and there is a flexibility in the order that can respond to the dynamics of stakeholder priorities. Actions that have a notable interlinkage with other Pathways have been identified and highlighted.

With the restructuring of actions, some renumbering has occurred compared to the original.

Figure 2

Explore the six roadmap Pathways

Collective actions	Company actions	Wider stakeholder ask
Pathway 1 **Design for circularity**		
1.1 Define what constitutes the design of a circular product and service *1.2* Set up an industry knowledge repository for circular electronics *1.3* Develop and roll out an education program and tools for circular electronics design	*1.4* Develop and implement circular transition tools within companies	*1.5* Create an enabling regulatory environment for the sale of circular products and services
Pathway 2 **Drive demand for circular products and services**		
2.1 Develop guidance for circular electronics procurement *2.2* Stimulate circular procurement of electronics at global scale *2.3* Quantify and communicate the value of circular products and services *2.4* Train and reward knowledge and the consistent application of circular procurement	*2.5* Commit to meeting the demand for circular products and services *2.6* Report on company circular procurement data	*2.7* Develop and harmonize circular procurement global reporting standards
Pathway 3 **Scale responsible business models**		
3.1 Explore consumer needs on circularity to drive demand and generate business value *3.2* Consistently measure and communicate to investors about the performance of circular business models *3.3* Assess Scope 3 GHG emission benefits of circular solutions *3.4* Adapt accounting for circular electronics	*3.5* Invest in circular business models with social and environmental impact *3.6* Utilize best practices on data sanitization *3.7* Enable independent repair providers and consumers to conduct appropriate repairs safely	*3.8* Ensure legal clarity on the liability for product defects and access to insurance for repair and refurbishment *3.9* Enforce labor rights and enable the formalization of companies and workers
Pathway 4 **Increase official collection rate**		
4.1 Strengthen convenient take-back and collection *4.2* Consolidate historic e-waste mapping and assess recoverability	*4.3* Engage informal actors and support their transition to formalized entrepreneurs *4.4* Tie take-back and collection to the business model	*4.5* Harmonize definitions and reporting for WEEE/EEE take-back and collection *4.6* Increase public-private cooperation in the development of effective EPR regulation
Pathway 5 **Aggregate for reuse and recycling**		
5.1 Accelerate progress towards the digitization of the PIC procedure under the Basel Convention *5.2* Pilot "trusted trader agreements" that ease the complexity of moving waste electronics to certified recyclers *5.3* Plan sorting, pre-processing and recycling operations at the regional and global level		*5.4* Improve the classification of waste at borders through capacity building *5.5* Move towards an insurance model for financial guarantees *5.6* Move to an opt-out system for transit countries and allow for flexibility
Pathway 6 **Scale secondary material markets**		
6.1 Develop data standards and definitions for secondary materials *6.2* Create an EHS assurance scheme for secondary materials *6.3* Standardize material tracking and provide traceability and sourcing transparency	*6.4* Commit to scale secondary material use in the long term	*6.5* Incentivize technology investments for meeting future secondary material demand *6.6* Incentivize the sale of secondary materials

0.1 Explore the implementation of value chain data exchange mechanisms to enable circularity

Pathway 1:

Design for circularity

Embedding circularity into product design is crucial to enabling a circular economy for electronic devices and equipment. This means designing for dematerialization, longevity, reuse and recyclability, and adopting specifications for sustainable materials and components, enabling value generation at each stage of a product's life cycle.

Since 2020, we have observed progress on Pathway 1. This includes a growing interest in circular design from both producers and customers, as well as maturing collaborations between organizations. Nevertheless, work in this area remains important.

The key barriers to circularity at this stage include:

- Lack of consistent, coherent industry-wide standards and definitions implementation for circular electronic products and services.
- Lack of a mandate for circular product design from company leadership.
- Lack of demand for circular electronic products and services.
- Lack of collaboration between product development stakeholders and life cycle partners.
- Insufficient actionable training for designers and engineers.
- Limited accessibility of best practices and case studies for circular product design at scale to serve as inspiration for companies to go beyond minimal compliance.

As product design is interlinked with all stages of the value chain, several barriers and actions discussed within other Pathways are equally relevant for driving responsible product design.

The following actions have been prioritized for advancing circularity through design.

Collective action

P1.1 Define what constitutes the design of a circular product and service

A common vocabulary across stakeholders is vital for implementing and evaluating a circular economy. Generally agreed and achievable principles for what circular design is are needed to drive harmonization efforts in standards, government policies, procurement practices and certification schemes. This will help bring consistency across the sector to achieve circularity-related goals.

Value chain stakeholders are going to collaborate to propose principles for evaluating circularity in products and services. These stakeholders include producers, retailers, refurbishers, product service and disposition companies, recyclers, importers, resellers and relevant public sector entities. Together, they can develop a North Star vision of what the industry transformation towards a circular economy should look like, creating a base reference for further standard, certification and regulatory development.

Based on this model, standardization institutions can develop industry-wide standards to define and assess circularity – incorporating product design and business model perspectives. This North Star should consider the context and associated characteristics of different electronics categories.

Collective action

P1.2 Set up an industry knowledge repository for circular electronics

To accelerate circular product design practices, an NGO or industry association can set up, curate and maintain an online repository of circular design materials. This can include standards, references and definitions on circular electronic products and services, eco-design policies and regulation for different regions. Beyond this, the repository can hold information and case studies on industry design best practices.

The repository should encourage and enable designers, marketers, distributors and other relevant actors to prioritize circular design criteria by providing them with accessible information on available tools.

Collective action

P1.3 Develop and roll out an education program and tools for circular electronics design

During product development, designers and other stakeholders are required to balance various requirements. Design for circularity can take many different forms, depending on the intended life cycle and recovery at end of life (e.g., durability, repairability, recyclability, use of recycled content, etc.) and often requires different, even contradicting, design solutions. In addition, requirements for product safety (e.g., flame retardancy), customer preferences (e.g., usability) and economic requirements (e.g., production cost) are also important.

It is critical to provide designers and product developers with the tools and capabilities to effectively evaluate circular design criteria as part of the product development process. To overcome the lack of industry-specific training on product design for circularity, businesses can collaborate with NGOs and education institutions to develop tools and training for designers and engineers. These can be rolled out as corporate training programs for professionals and consumers, or as part of relevant study programs at universities.

Company action

P1.4 Develop and implement circular transition tools within companies

A company transformation to a circular business is extraordinarily complex. Certain starting principles, such as "use of circular resources", "design for circularity" and "ensuring material recovery", are helpful. However, by specifying and translating what this means for a particular product, these principles can lose meaning if the full intended circular life cycle of the product is not considered.

Without an in-depth strategy for how products will be sold, used, collected, repaired, reused, refurbished or recycled, designers have very little context when it comes to developing circular design solutions. Therefore, rather than starting with design, producers need to approach circularity by carefully considering how products will perform on circularity throughout their life cycle, balanced with other key parameters such as cost, safety and performance.

The development and implementation of business tools, like a "circular value proposition canvas", could help top-level management structurally consider how to practice circular business. It could further help them engage and direct all relevant company stakeholders, including design teams, to contribute within their capacity to the central circular business transformation. These tools could either be developed by companies internally or through industry collaboration for subsequent individual use.

Wider stakeholder ask

P1.5 Create an enabling regulatory environment for the sale of circular products and services

Demand is the primary driver for circular product and service development and is vital to ensuring circularity is a priority for corporate decision-makers. Policies and regulations that support the development and uptake of circular products and services are needed to accelerate the transition to circular electronics.

Governments can build on the momentum of the EU Green Deal and the new Circular Economy Action plan – under which legislation is currently proposed. Globally, governments need to further develop and implement a regulatory framework that incentivizes development and uptake of circular products and services while not over-regulating the detailed execution. This can include, but is not limited to, value-added tax (VAT) reductions, extended product support periods or modulated extended producer responsibility (EPR) fees – where not already in place.

Interdependent action:
P6.6 – Incentivize the sale of secondary materials

Pathway 2:

Drive demand for circular products and services

Public and private sector procurement (B2B and business-to-government (B2G)) are key levers for creating demand for circular products and solutions. Collectively, the volume of B2B and B2G purchasing helps incentivize manufacturers to scale existing circular solutions and business models and innovate. These models can then serve as trailblazers for more complex and diffuse B2C markets.

There are some early activities, such as public and private requests for proposals, that include a circularity and sustainability in the bidding process; however, there are still many barriers that need to be addressed.

The key barriers to circularity in private and public sector procurement include:

- Limited understanding of circularity, its benefits and how circular procurement differs from – and complements – existing sustainable procurement requirements.
- Limited integration of circular requirements into organizational procurement guidelines.
- Lack of organizational commitment to a circular economy, leading to exclusion of circular targets for procurement departments.
- Lack of industry-wide commitment to selling circular products and services.
- Misconceptions about inferior performance, data security, warranty limitations and a "new is best" attitude.
- Missing tools and language to quantify and communicate the benefits of circular procurement (and complexity to develop these).
- Lack of integration into global environmental, social and governance (ESG) reporting metrics.
- Lack of training for procurement professionals.

The following actions have been prioritized for increasing demand for circular products and services.

Collective action

P2.1 Develop guidance for circular electronics procurement

Integrating circularity criteria into organizational procurement processes can drive major purchasers of electronic products and services towards increased circularity, influencing overall market demand. NGOs, together with academic and standards organizations, can apply the definition of circular products and services to the procurement context, defining circular products and services for purchasers. This includes developing globally applicable purchasing preferences, standards and guidelines (aligned with the joint definitions as per Pathway 1).

This guidance will help public and private sector procurement specialists integrate circularity criteria in their organization's procurement processes. It will also help them reconsider specifications that prevent circularity, such as those that only allow tendering of new devices and equipment. In line with the Circular Electronics System Map, asset disposition can also play a critical role for circular procurement to avoid linear practices at end of life. Guiding principles could either be included in procurement guidance or developed separately in tandem.

Collective action

P2.2 Stimulate circular procurement of electronics at global scale

Clear commitments to circular procurement by governments, companies and other large buyers can stimulate circular procurement by demonstrating relevance and creating momentum for other organizations to raise their ambitions. Commitments also provide direction for employees and create a sense of urgency around defining clear responsibilities and developing implementation plans. NGOs could launch a global campaign for countries and private sector leaders to commit to circular procurement.

Commitments could include setting a defined annual percentage spend on circular information technology (IT) products and services; they should highlight the impact of circular procurement on the global UN Sustainable Development Goals (SDGs). In addition, governments and companies should consider integrating circular procurement into strategies for supply chain continuity, climate resiliency and in upcoming policies (e.g., the EU Green Deal).

Collective action

P2.3 Quantify and communicate the value of circular products and services

Fact-based communication about the climate, social, environmental and economic benefits of circular procurement helps raise awareness. It also creates a sense of urgency for changing mindsets from the status quo of a linear model towards one of circularity.

NGOs, with support from research organizations, can develop tools that help quantify the environmental, social and economic benefits of circular products and services.

They can also highlight the value case and associated organizational benefits for buyers. Increased awareness among consumers supports uptake of organizational and governmental policies that stimulate circular electronics.

In addition to clarifying and quantifying benefits, these tools should include guidance on terminology used to communicate these benefits to consumers.

Collective action

P2.4 Train and reward knowledge and the consistent application of circular procurement

Training and knowledge sharing can support purchasers to integrate guidance on circular electronics procurement into their own organizational processes. This includes category management, process improvement and demand management.

NGOs, industry associations and manufacturers can offer training resources to increase uptake. This could include training for procurement specialists on the definition of circular products and services, the modification of sourcing strategies and the application of circularity preferences and requirements in procurement decisions. A circular procurement certification and recognition program could highlight and reward best practices, incentivizing wider uptake of circular electronics procurement.

Company action

P2.5 Commit to meeting the demand for circular products and services

A clear commitment to circular electronics from producers, especially manufacturers, is vital. It will signal to purchasers that a wide range of products and services will exist that meet circular procurement requirements. To meet demand, producers need to integrate circularity into their corporate strategies, adopt circular design and sourcing policies, and partner with purchasers on circular products and services (e.g., via take-back programs).

Purchasers should be encouraged to explore innovative commercial models that promote mutual benefits with producers (e.g., multi-year performance-based service contracts for hardware assets). NGOs should be prepared to support producers' commitments, where considered appropriate and helpful (e.g., featuring case studies, speaking opportunities on transitional progress, shared target-setting, etc.).

Company action

P2.6 Report on company circular procurement data

ESG reporting is growing increasingly relevant with regard to stakeholder engagement and investment decisions. Annually, ESG factors are systematically included in financial analysis on USD $2.5 billion worth of investing assets – a 143% growth since 2016.[19] To attract and retain investors, as well as satisfy stakeholders, companies will increasingly need to show sustainable, and circular, procurement progress.

Companies cannot manage what they do not measure. It is important to track and report data related to circular procurement goals and policies. Reporting would include both the procurement of materials necessary for finished products sold, as well as internal procurement practices for business operations on technology purchased. Both measurements will facilitate tracking of progress against goals and allow for planning and/or course corrections where needed.

Wider stakeholder ask

P2.7 Develop and harmonize circular procurement global reporting standards

Circularity in raw material sourcing and product and service procurement is currently not integrated into existing ESG reporting guidelines – leading to a lack of global reporting. The integration of circular sourcing and procurement in ESG accounting standards (e.g., GRI, SASB) and protocols by ESG reporting organizations (e.g., CDP) would lead to more informed assessments of the progress or, lack thereof, towards circularity. Regular reporting would enable setting, tracking and achieving circularity goals at scale.

To support this process, consideration could be given to initiatives such as the collaborative efforts between CDP, CDSB, GRI, IIRC and SASB.[20] It could also include existing guidance or policies on non-financial reporting, such as the CSRD or the Disclosure and Engagement Guidance to Accelerate Sustainable Finance for a Circular Economy in Japan.[21]

Pathway 3:

Scale responsible business models

Responsible business models for circularity determine the ability of the company or value chain to unlock the full economic potential of circular electronics. They create and orchestrate the ecosystem that realizes the benefits of products and services designed for circularity.

These include the longer, more efficient use of products and materials, as well as the implementation of effective strategies to ensure respect for human rights throughout the value chain. This Pathway focuses on responsible circular business models for electronics, especially in the use phase. This includes product use extension, sharing platforms and product-as-a-service.[22]

The key barriers to responsible circular business models for the use phase of electronics include:

- Missing transparency on demand, opportunity and business value.
- Limited access to financing.
- Limited access to repair and refurbishment for consumers.
- Knowledge gap with users and end users on safe, simple data sanitization options, resulting in hoarding of unsanitized devices.
- Lack of harmonized procurement policies and due diligence requirements across international and national value chains.

The following actions have been prioritized to scale responsible, circular business models for the use phase of electronics.

Collective action

P3.1 Explore consumer needs on circularity to drive demand and generate business value

Enhancing current and developing value propositions of circular products and services is vital to driving demand and ensuring circular business models offer business value. The key will be to center this development around consumer needs. The consumer research and marketing teams of electronics manufacturers and retailers will play an important role in exploring and understanding those needs and translating them into opportunities. Marketing teams will also require training on how to drive the appeal and market position of such products and services, and on how to substantiate green claims. NGOs could work with research organizations to generate industry-wide consumer insights to support a larger transition towards circular business models.

Collective action

P3.2 Consistently measure and communicate to investors about the performance of circular business models

To support the transition to a circular electronics industry, investors are adapting their understanding of value creation, risk and short-term versus long-term profits. It is the task of producers to consistently measure and communicate circular product and service performance to investors, demonstrating the financial success of circular electronics to attract and sustain investment. Standardized definitions and metrics for circular products and services (see Pathway 1) can help producers set growth targets for more circular portfolios and underpin financial performance with metrics such as percentage of revenue and profits from responsible circular offerings.

Collective action

P3.3 Assess Scope 3 GHG emission benefits of circular solutions

By 2040, the ICT sector is expected to produce around 14% of emissions globally.[23] Depending on the product, Scope 3 emissions can constitute 50%–90% of an organization's total GHG emissions.[24] Though it is widely accepted that Scope 3 emissions must be addressed, they are also the hardest to measure and tackle.

Further efforts are needed to establish a common baseline and better understand the GHG emission contribution of electronic devices in different industries. Focus should be on naming and quantifying the reduction potential of circular solutions on an organization's Scope 3 emissions. This will involve development and use of corresponding emission and circularity standards, including industry-specific guidance on harmonized reporting methods. Another focus area could be the question of how to best verify or audit these findings. Development work is ongoing in both areas across and beyond the CEP partner organizations, such as the Scope 3 Guidance for Telecommunications Operators,[25] developed by GSMA, GeSI and ITU, as well as the PACT Pathfinder Framework,[26] powered by WBCSD.

Collective action

P3.4 Adapt accounting for circular electronics

Circular business models and circular electronics procurement can lead to an abrupt change in cash flow statements and balance sheets when introduced. This becomes particularly clear with the example of product-as-a-service models that have increased working capital demand and cash flows spread across a longer period of time. In addition, rules on depreciation and residual value estimation are biased towards a linear economy. They can, for example, incentivize large buyers of electronics to regularly replace used IT equipment with new products to exploit tax benefits. They can also present a biased picture of the financial health of providers of second-hand and refurbished products or products-as-a-service. Adaptation of current accounting practices through changes to the U.S. Generally Accepted Accounting Principles (GAAP) and International Financial Reporting Standards (IFRS) can further support circular business models. For example, this can include guidance for estimating residual values of assets or for sizing the cost of repair and refurbishment.

Company action

P3.5 Invest in circular business models with social and environmental impact

More investment in responsible, circular business models is needed to improve the social and environmental impact of the electronics industry and help accelerate the transition to circular electronics. Producers can invest in, or partner on, the development of alternative business models that prioritize design for circularity, sourcing circular materials and exploring alternative take-back and collection models that facilitate reuse, use life extension or recycling.

Public producer commitments to circularity can help drive demand (see Pathway 2). Financial institutions need to act responsibly and increase financing options for circular business models. This can be achieved by holistically integrating circularity and human rights into assessments of financial and ESG performance.

Company action

P3.6 Utilize best practices on data sanitization

Reuse, refurbishment, remanufacturing and high-value material recycling depends on the timely take-back of unused electronic devices and e-waste. Fears surrounding data misuse and insecurity through collected end-of-life devices is a serious deterrent for users or end users when it comes to handing over their old electronics. Standards and certifications are in place to ensure sanitization processes with reliable technology are carried out through certified facilities. However, the self-education for consumers that is required to fully understand which sources to trust leads to many devices being kept but not used by consumers, or being disposed of in ways that offer little or no value retention.

Electronics manufacturers can integrate a safe data sanitization solution in all electronics that store personal data. Users should be enabled to perform the data sanitization themselves. Clear communication about available data sanitization options can promote their use and reduce insecurities.

Across jurisdictions globally, risks regarding unreliable data sanitization are addressed through voluntary frameworks, standards and guidelines, such as EPEAT, TCO, IEEE 2883 or NIST SP800-88r1. Engagement of the private sector in these policy developments is critical to ensure they are effective and constructive.

Company action

P3.7 Enable independent repair providers and consumers to conduct appropriate repairs safely

Electronics manufacturers need to support product use extension by partnering with independent repair and refurbishment providers. They can provide training and certification of technical competence to professionals to enable effective, accessible provision of repair and refurbishment services to customers.

Leveraging the existing right-to-repair movement and circular product design, there may also be certain types of repairs that could be safely performed by the consumer. Electronics manufacturers will need to determine which products are suitable for this. Based on their assessment, repair manuals and replacement parts can be produced to help consumers perform simple and safe repairs themselves.

Since the launch of CEP, legislative developments have taken place in both options for repair, such as the Digital Fair Repair Act[27] in New York State and the Repairability Index[28] in France. It is important that governments engage the private sector in these policy developments to ensure they contribute to productive solutions and avoid stalling progress for companies who are ahead of legislation.

Interdependent action:
P3.8 – Ensure legal clarity on liability for product defects and access to insurance for repair and refurbishment

Wider stakeholder ask

P3.8 Ensure legal clarity on the liability for product defects and access to insurance for repair and refurbishment

Repair providers play a key role in the circular economy, providing fast, straightforward product services to local customers. Professional refurbishment providers, including manufacturers, complement these services at the regional, or even global, level. Currently, there is a lack of clarity about who is responsible for repairs under the manufacturer's warranty, the voiding of warranty, the safety of repairs, and repairs conducted by individuals outside of warranty. This includes not only physical defects, but also digital defects, such as malware. In addition, poorly repaired products reflect primarily on the brand owner.

These structural problems limit the growth of the repair and refurbishment sector and accessibility of these services for customers. The European Commission's plans to establish a "right to repair" for electronics will require the definition of responsibilities.[29] Policies clarifying liability of repair and refurbishment providers and manufacturers for any social, environmental or financial damages resulting from a repaired product – as well as work towards harmonizing product liability regulation related to product use extension services at the regional and global level – could help address the issue. The "right to repair" legislation currently in place in some countries and U.S. states can serve as an example. Collective insurance schemes for repair operators could also be considered to further support repair and refurbishment markets.

Wider stakeholder ask

P3.9 Enforce labor rights and enable the formalization of companies and workers

Informal repair providers, collectors and recyclers are dominating the electronics value chain in many emerging markets; markets that often have poor working conditions and low environmental standards. To maximize positive social impact and advance decent work in the transition to circularity, there is a need to promote respect for labor rights. This includes ensuring safe, adequate working conditions, decent pay and dialogue between actors ranging from government entities to employers and workers' organizations (including informal workers).

To support the formalization of enterprises, governments can offer incentives such as reduced taxes during transition or access to social security, etc. Furthermore, consistency of due diligence requirements across international and national frameworks is needed to support the development or reinforcement of assurance processes. All companies in the electronics value chain need to ensure human rights are respected throughout their value chains. Calibrating those standards and deploying them in the development and scaling of circular business models needs to be a priority.

Interdependent action:
P4.3 – Engage informal actors and support their transition to formalized entrepreneurs
P6.2 – Create an EHS assurance scheme for secondary materials

Pathway 4:

Increase official collection rate

Improving the take-back rate of electronics at the end of their useful lives is essential for achieving 100% responsible repurposing of sold electrical and electronic equipment. Repurposing includes the reuse of products and components through repair, refurbishment, remanufacturing, reuse/reprocessing or parts harvesting and the high-quality recycling of materials when reuse is not a viable option.

The focus is on increasing the return rate of devices and equipment that have been discarded by consumers, including bulk consumers/large buyers (B2B, B2G) and individual consumers/households (B2C). In 2022, the documented formal collection rate was 22.3%, with strong regional variations.[30]

The key barriers to increased collection and responsible repurposing include:

- Lack of transparency throughout regional take-back ecosystems globally.
- Lack of formal take-back infrastructure in developing countries and emerging markets, connected to a lack of finance for such infrastructure.
- Lack of outcome-oriented policy and regulation, or weak enforcement of these policies if they exist.
- Lack of legal obligations for retailers when it comes to EPR provisions in e-waste regulation.
- Limited application of sustainable financing mechanisms to policy and regulation on e-waste.
- Low uptake of collection and recycling targets being enshrined in e-waste regulation.
- Lack of global consistency in approaches to regulating and reporting on e-waste.
- Inconvenience and lack of incentives to encourage consumers to properly return electronics, which, in turn, increases access to waste costs for collectors and recyclers.

The following actions have been prioritized to increase the official collection rate.

Collective action

P4.1 Strengthen convenient take-back and collection

The actual return of electronics that are no longer used by consumers (B2B, B2C and B2G) is a critical factor in take-back and collection. In addition to the major barrier of data security concerns (see Pathway 3), a lack of clarity on responsibility for take-back of equipment, and the financial costs or inconvenience associated with the returns process limit collection rates.

To address these issues, producers, in collaboration with local governments, retailers, non-profit organizations and waste companies, can incentivize consumers to return equipment through investing in more convenient drop-off locations. They can also explore ways to reward correct behavior. Industry peers can take the lead in collaboratively exploring how to create appropriate collection pathways for different regions and product types and how to implement these through pilots and scaling.

Better communication of EEE on specific take-back opportunities and embedding messaging about take-back opportunities into the customer journey can raise awareness. Moreover, collection channels need to be explicit about the guaranteed data sanitization of their subsequent value chain partners. This is in relation to product and material recovery and will help assure customers that any remaining data on their device will be destroyed. To improve take-back rates from large purchasers, producers can consider integrating buy-back agreements, or product-as-a-service models, into purchasing contracts. Finally, producers could make agreements with small, third-party repair centers to boost collection and take-back of specific boards and circuits with components that contain precious metals and protected designs.

In emerging markets, there needs to be a clear focus on implementing regulation (see P4.6) and boosting convenient take-back and collection schemes. To articulate opportunities for (further) development of regional and local collection and take-back systems, a thorough mapping and understanding of the current infrastructure and available channels is recommended.

Collective action

P4.2 Consolidate historic e-waste mapping and assess recoverability

Most actions outlined in this roadmap are targeted towards increasing responsible and efficient resource use, and avoiding dumping of e-waste going forward. However, industry players are aware that a significant amount of e-waste has been improperly disposed of or accumulated in large storage facilities in past decades. With the support of researchers, producers can consolidate data about historic e-waste to get a better picture of locations and volumes, and assess recoverability of historic waste. This will be used to develop regional strategies for efficiently recovering these resources.

Company action

P4.3 Engage informal actors and support their transition to formalized entrepreneurs

In many developing countries and emerging markets, informal workers and worker networks dominate WEEE collection and recycling. While transitioning the informal sector (see Pathway 3), governments should do more to formalize unofficial take-back activities to ensure decent labor and environmental standards. In cooperation with governments, NGOs and development organization, industry players can create frameworks for informal workers to participate in formal markets. They can also pilot financial mechanisms for informal actors to formalize their practices in a decentralized circular system. Increasing their financial return and the speed of payment will be key to developing an effective incentive.

These actions support the transition of informal actors to formalized entrepreneurs and enable improvements in health and safety practices. Building on successful take-back solutions, collection networks and logistics developed by the informal economy can ensure easy access to and availability of take-back for many more consumers. In collaboration with NGOs and international organizations, certified recyclers can expand current collection work and develop pilot projects that create business models for buying e-waste from informal collectors, ensuring safe material processing.

Interdependent action:
P3.9 – Enforce labor rights and enable the formalization of companies and workers

Company action

P4.4 Tie take-back and collection to the business model

Integrating solutions for take-back and collection into the business model is an additional driver of enhanced collection rates. Circular business models based on ownership retention, such as leasing or pay-per-use models, are one option. However, take-back solutions can also be added to existing models. Manufacturers can identify viable solutions (e.g., through agreements with universities and local research centers) for integrating take-back and collection into their value propositions. They can also invest in creating digital solutions that facilitate take-back (e.g., reverse vending machines, product passports, etc.).[31]

Wider stakeholder ask

P4.5 Harmonize definitions and reporting for WEEE/EEE take-back and collection

A first step towards harmonizing global approaches to take-back and collection involves improving consistency in reporting and measurement. International research and reporting initiatives (e.g., Global E-waste Statistics Partnership, GRI, OECD, UN Statistics Division, SASB, etc.), in cooperation with governments, can drive convergence on definitions and reporting for WEEE/EEE take-back, collection and recycling rates. It is recommended to start at the national or regional level and move towards creating global standards.

Wider stakeholder ask

P4.6 Increase public-private cooperation in the development of effective EPR regulation

EPR has proven to be a successful regulatory framework in WEEE management. This is true of countries that lack legislation on e-waste management, and where private sector-led collection schemes are difficult to establish. In these geographies, strong public-private cooperation is needed to develop effective EPR regulation that encourages the right actions by all stakeholders. Governments can benefit from support by experienced producer responsibility organizations, manufacturers and recyclers. They can learn from models that have been successfully implemented in other developing countries and roll these out to vastly increase the global coverage of e-waste legislation. Public-private cooperation is also key to improving enforcement of existing regulation or enhancing regulation to drive better outcomes (e.g., through avoiding inconsistencies or tailoring policies to the type of equipment.

Pathway 5:

Aggregate for reuse and recycling

A reverse supply chain moves end-of-use electronics from areas with a surplus to areas with the capacity for high-quality, safe and efficient repurposing (e.g., repair, refurbishment or recycling).

Aggregating used EEE and WEEE is particularly important, as high-quality repurposing of an increasingly varied array of products – from smartphones to capital equipment – requires specialization and investment in all links of the value chain. To facilitate repurposing at scale, the responsible, transboundary movement of used electronics will need to enable economies of scale based on efficient and globalized reverse supply chains.

International regulation for shipment of circular resources

Basel Convention on the control of transboundary movements of hazardous waste and their disposal

The Basel Convention is a multi-lateral treaty established in 1992 and signed by 188 parties. Members of the convention have committed to control transboundary movements of hazardous waste and, since December 2019, to ban exports from developed to developing countries to prevent illegal dumping. Every transboundary movement of hazardous waste requires an approval process based on the Prior Informed Consent (PIC) procedure. PIC processes are administered by authorities of the importing and exporting country as well as the transit countries, giving all countries the right to refuse shipments of unwanted waste. The Basel Convention is complemented by other regional initiatives such as OECD, EU WSD or US special arrangements.

Key barriers to responsible transboundary movement include:

- Lack of capacity and effective implementation of the Basel Convention in various countries.
- Divergent implementation of the Basel Convention at a national level, leading to system complexity.
- Different views around the level of control for the trade of used EEE and WEEE that persist despite the revision of Technical Guidelines in the Basel Convention. This revision aims to provide more clarity on definitions and classifications for regulatory terms such as “non-waste” (used EEE) and “waste” (WEEE), and “hazardous” and “non-hazardous waste”.
- Largely paper-based permitting process for PIC that make it challenging to act quickly on minor changes in product or shipping routes.
- Illegal trading of WEEE and continued illegal dumping in developing countries.

As a result of these barriers, reverse logistics for used electronic products are at least 31% more costly than outbound logistics for new products. If classified as “hazardous”, they are up to 190% more costly.[32]

The following actions have been prioritized for facilitating aggregation of EEE or WEEE for reuse and/or recycling. This will also ensure the highest social and environmental standards in transboundary shipments, supporting the principles and commitments of the Basel Convention.

Collective action

P5.1 Accelerate progress towards the digitization of the PIC procedure under the Basel Convention

Currently, administrative requirements for transboundary shipments are largely paper based. Original notification documents must be signed in hard copy and posted to competent authorities in the importing, exporting and transit countries for approval. A strong digitization effort for PIC processes can significantly streamline processes, reducing transaction costs for legitimate shipments and preventing delays. This includes points of import and export, as well as every point along the reverse supply chain. Members of the Basel Convention should continue to prioritize and accelerate planned digitization efforts.[i] Partnerships with other international e-government initiatives, logistics providers and other companies, as well as groups such as the Global Alliance for Trade Facilitation and the Prevent Waste Alliance can help bring global best practices to the PIC procedure. Industry can play an important role in ensuring solutions are made possible by actively engaging in their development.

Collective action

P5.2 Pilot "trusted trader agreements" that ease the complexity of moving waste electronics to certified recyclers

Waste equipment flows tend to follow a path of least resistance. Efforts to assure paths lead to a formal repurposing facility and not to the informal economy are critical. Based on bilateral arrangements of competent national authorities, logistics providers, electronics producers and recyclers can set up "trusted trader agreements". These are for shipments that channel used equipment from pre-approved collectors or processers (including original equipment manufacturers with collection programs) to pre-approved and certified recovery facilities under a trusted trader system. This would cover shipments of waste intended for reintroduction of materials into the circular economy.

The system enabling this needs to be transparent and robust and could be created through a multi-stakeholder process. Shipments should not be possible to countries that do not wish to receive waste. Regional agreements, such as Africa's Bamako Convention, will need to be respected. Although such agreements are made between countries, it is the industry that would be obligated to follow implementation. There is current support for the concept of such agreements, but no pragmatic model of what it could look like. A group of experts could come together to design a model arrangement for a resource recovery lane or equivalent, consulting with trade, customs, business and non-profit leaders. The arrangement will be delivered as inspiration to champion governments to take forward. Countries would be able to pursue trusted trader bilateral or regional agreements under Article 11 of the Basel Convention.

[i] The Basel Convention Secretariat has initiated a working group on exploring electronic approaches to notification and movement of documents by request of the COP, albeit with a medium priority in the workplan for the period 2022–2023 (Source: UNEP-CHWOEWG.12-14.English.pdf).

Collective action

P5.3 Plan sorting, pre-processing and recycling operations at the regional and global level

As well as documented challenges with cross-border trade of circular goods and materials, the global reverse supply chain system for electronics could be optimized through strategic planning of e-waste management infrastructure. National, or even regional, waste volumes can be too small to attract investment in specialist recycling facilities, leading to a lack of competitive recycling infrastructure in emerging regions.

Collaboration between regional governments to develop a strategic perspective on e-waste management could help address this issue. They can engage with specialist recyclers to establish local centers for sorting, pre-processing and recycling, combining e-waste volumes from several countries to enable economies of scale and attract expertise and investment. Where local or regional facilities are not economically viable, they can consider how to enable access to international end-processing facilities (see Pathway 5). To encourage development of quality recycling infrastructure in emerging markets and developing countries, governments will also need to consider incentivization. This could be through using certified formal recyclers or minimizing business risks associated with illegal leakage of materials into the informal economy.

Depending and interdependent action:
P6.5 – Incentivize technology investments for meeting future secondary material demand

Wider stakeholder ask

P5.4 Improve the classification of waste at borders through capacity building

Collected electronics destined for repair, refurbishment or recycling are categorized at the border as either "non-waste", "waste" or "hazardous waste". Definitions are often interpreted (or misinterpreted) differently across jurisdictions, leading to uncertainty around the classification of waste. International organizations can collaborate with policymakers and customs officials in countries that are part of the global electronics value chain. They can provide training and build capacity on the critical assessment of incoming and outgoing shipments and the application of the Basel Convention. The training should include implementing the new Harmonized System (HS) customs codes for electrical and electronic waste that took effect in 2022. More sophisticated traceability systems could also enhance waste management at granular level.

Wider stakeholder ask

P5.5 Move towards an insurance model for financial guarantees

If a company wants to make a shipment subject to the notification procedure, they must first provide funds in escrow to cover the shipment's storage, return and/or treatment in case of non-compliant shipments. This financial guarantee is linked to each individual notification request. The money must be accessible until the final certificate of environmentally safe repurposing is given. To avoid locking up significant amounts of capital and simplify regulatory procedures, members of the Basel Convention should consider regulatory adjustments that allow for the financial guarantee system to be converted to an insurance system. Guarantees are only activated at a rate of 0.01%, so it is likely the insurance sector would be willing to serve this space.[33] Currently, updates on the approach for financial guarantees in the Convention are being discussed, opening a window of opportunity to advance it.[34]

Wider stakeholder ask

P5.6 Move to an opt-out system for transit countries and allow for flexibility

The Basel Convention requires that all transit countries give explicit consent to every transboundary shipment by undertaking the full PIC procedure. According to company disclosures, transit countries seem to be the least likely to go through this procedure as they have the least at stake in the process. Members of the Basel Convention need to evaluate an opt-out system for transit countries that should be notified of planned shipments – retaining the right to block them. If the country does not block the shipment within an agreed timeframe, this should be considered as tacit consent to the transit. There is ongoing work on this topic.[35]

Pathway 6:

Scale secondary material markets

Increasing the availability, quality and responsible sourcing of secondary materials and scaling recycled content in new product manufacturing are key levers for reducing demand for virgin materials and closing the loop on materials for circular electronics.

Convening the manufacturers who drive demand for secondary materials with the recyclers and processors that supply them will help formalize the sector, achieve economies of scale and drive market competitiveness of secondary materials.

Key barriers to increasing high-quality recycling and the use of recycled content in manufacturing include:

- Lack of data standards and definitions for secondary materials.
- Lack of EHS assurance to responsible labor and environmental practices in the recycling sector.
- Lack of transparency on the origin and content of scrap material.
- Lack of transparency on long-term supply and demand.
- Lack of investment in recycling technology.
- Lack of competitive, quality recycling infrastructure in emerging markets, which is required to reduce the risk of pollution and problematic working conditions associated with the improper end-of-life handling of WEEE in informal channels.

Solutions to some of these barriers have been described through actions categorized under Pathways 4 and 5. The following additional actions have been prioritized to enable scaling of efficient and responsible secondary material markets.

Collective action

P6.1 Develop data standards and definitions for secondary materials

Industry-wide standards and definitions on the characteristics of secondary materials are critical for recyclers to provide the same level of material performance assurance as virgin material suppliers. Categories of focus should include: material quality and quantity,[ii] chain of custody[iii] and production characteristics.[iv] Where limited alignment on these key definitions was seen as a serious barrier during development of the original CEP Roadmap, current perception is that many of the ambiguous concepts have evolved into more concrete and commonly understood language. This is reflected in ISO 14021, SCS Recycled Content Standard. As more standards become available (such as ISO 59020, currently under development), these can be compiled and shared for reference.

Where gaps continue to exist, multi-stakeholder taskforces, including recyclers, designers and sourcing specialists from manufacturers, can form credible taskforces responsible for defining scope, data standards and definitions for key categories.

ii i.e., volume, material type, recycled content, material composition including harmful components, performance and purity.

iii i.e., origin, destination, previous owners, facility and country.

iv i.e., EHS practices, recycling processes, material handling, workers' safety and environmental management systems.

Collective action

P6.2 Create an EHS assurance scheme for secondary materials

There is a lack of EHS assurance for the repair, refurbishment, remanufacturing and recycling sector. It makes the purchasing of secondary materials an often-unacceptable business risk for many electronics manufacturers as it bypasses their due diligence processes in other parts of the value chain. This curbs demand growth and slows integration of more recycled content into new electronic products.

Certain EHS standards are available for early stages of recycling, but they do not provide full life-cycle due diligence for material procurement. The objective should be to drive consistency in EHS expectations for the recycling sector, especially in relation to engagement with the informal sector. The long-term imperative is to design and implement a validation scheme that provides onsite due diligence and assurance to EHS practices. Data standardization and reporting schemes could be expanded to include verification of EHS assurance in secondary material sources.

Interdependent action:
P3.9 – Enforce labor rights and enable the formalization of companies and workers

Collective action

P6.3 Standardize material tracking and provide traceability and sourcing transparency

Standardized material tracking and traceability can help overcome the lack of information about origin and routes of recovered materials. It can also improve assurance on material performance and EHS standards. As a first step, material suppliers, electronics manufacturers and recyclers – with the support of standards organizations and auditors – can define standardized technical data sheets. These can be applied at all tiers of the value chain, using virgin materials as a benchmark. They can then convene parties that are interested in the collaboration to define necessary data,[v] identify data sources, transferability and confidentiality, and align on reporting mechanisms and processes. The ability to trace recycled content to a level of assurance that wasn't sourced from poor EHS practices can be developed over time.

Depending and interdependent action:
P0.1 – Explore the implementation of value chain data exchange mechanisms to enable circularity

Company action

P6.4 Commit to scale secondary material use in the long term

Long-term commitments by manufacturers to procure recycled content would inspire confidence among recycling industry players to invest in technology that creates more reliable supply chains. Commitments and targets for secondary material demand should be long term so that supply from recyclers, smelters and processers can be developed to meet demand. Industry associations, universities and research centers, or NGOs, can support in creating space for designers from electronics manufacturers and recyclers to collaborate. This can allow them to focus on overcoming technical barriers related to the use of secondary materials and to increase transparency on current and future demand for materials – especially scarce and rare earth metals, mass metals and plastics.

Depending and interdependent action:
P1.3 – Develop and roll out an education program and tools for circular electronics design

[v] e.g., chain of custody, origin, volume, quality, EHS standards.

Wider stakeholder ask

P6.5 Incentivize technology investments for meeting future secondary material demand

Certain conditions currently limit the financial viability of recycling operations and incentives for investment in new technologies and infrastructure. These include unstable scrap material flows (see Pathway 5), decreasing precious metal contents, increasing material complexity and the significant costs of compliance and de-pollution. To ensure future demand for secondary materials can be met, governments and financial institutions should create financial support mechanisms. This can be for technology development in the recycling industry (including chemical recycling), especially automated sorting, and pre-processing infrastructure that can handle advancing product and material complexity. Because demand for recycling is driven by secondary raw material demand from producers, it is key to align the two industries. In addition, better enforcement of e-waste regulations would support compliant recyclers by preventing undercutting of market prices by actors not following EHS standards.

Depending and interdependent action:
P2.5 – Commit to meeting the demand for circular products and services
P5 – All actions (reverse logistics enable economies of scale in recycling)

Wider stakeholder ask

P6.6 Incentivize the sale of secondary materials

In addition to financial support for investment and better enforcement of social and environmental regulations, incentives for the sale of secondary materials can help accelerate the transition from virgin material production. This is especially relevant where secondary material production exceeds that of virgin materials. This can be caused by value chain complexities (e.g., regulatory processes related to reverse logistics, see Pathway 5) or lower economies of scale. Downstream incentives for circular products should be combined with upstream incentives for circular materials and supported by policies that increase the sale of recycled materials (e.g., tax reductions, subsidies) during the circularity transition.

Depending and interdependent action:
P2.5 – Commit to meeting the demand for circular products and services

Cross-pathway theme

This edition of the CEP Roadmap recognizes the field of data exchange across the value chain as one of substantial public and private sector development that crosses all pathways.

Digital Product Passports (DPPs), and similar data exchange mechanisms, are expected to increase transparency across supply chains and for the general public. This will empower informed decisions by different stakeholders throughout the product life cycle. Therefore, data exchange mechanisms could become an important lever in the industry transition to circularity, helping alleviate key barriers across the six Pathways. They can also support the emergence and scaling of new circular business models for electronics.

Collective action

P0.1 Explore the implementation of value chain data exchange mechanisms to enable circularity

Our understanding of potential value chain data exchange applications to enable electronics circularity is expanding beyond material tracking, traceability and sourcing transparency (see action P6.3). This is reflected in major policy developments, e.g., the EC's proposal to create DPPs that make product-related information available across the entire product life cycle among supply chain businesses, authorities and consumers. The first product groups, including electronics, are expected to be affected by this regulation in 2026/27.

Many DPP elements, such as scope, data requirements and technical requirements, are still under development. Industry players, supported by NGOs and other relevant stakeholders, need to continue proactively helping shape such elements. They must also address some of the emerging barriers, such as data complexity, availability, standardization, interoperability and confidentiality.

Companies can then collaborate in testing the operationalization of data exchange for circularity across their value chain(s). When doing so, they can build on existing and/or evolving standards and protocols, sector guidelines and frameworks and learn from other value chain data exchange initiatives. Early engagement would also allow companies to prepare for upcoming regulatory requirements and identify new business opportunities.

Pre-requisite actions:
P6.1 – Develop data standards and definitions for secondary materials
P6.3 – Standardize material tracking and provide traceability and sourcing transparency

Depending and interdependent actions:
All other actions

Measuring progress against CEP Roadmap actions

The CEP is an action-oriented initiative, seeking ways to measure its contribution towards a circular electronics industry.

It intends to take a meaningful, yet pragmatic, approach that acknowledges the limits of what information is realistically available, as well as the resources needed to acquire reliable and representative data.

The CEP progress measurement framework logically follows the roadmap structure and action levels.

Progress on collective actions

Twenty collective actions are at the heart of CEP's purpose as a collaboration and coordination platform. This is where we can establish whether the identified industry transition barriers are being relieved on an action-by-action basis, based on the following principles:

1. All actions on the roadmap contribute equally to overall progress.
2. All collective actions have a pre-defined success definition.
3. For each project it initiates, CEP determines the expected contribution towards resolving the specific action. For some projects, this will be 100%, when they present a full solution to the action. However, most projects will only address a certain part of an action (i.e., a specific product group or one particular step in the process towards resolve). Given the ambitious nature of the roadmap actions, most will not be possible to resolve with just one project.
4. KPIs are determined on a project level, both for the output of the project (the direct deliverable, i.e., a report publication) as well as for the outcome (the purpose for which the deliverable was developed, i.e., number of readers, literature references, adoption rate, etc.).
5. As projects get completed, progress on the KPIs drives a certain percentage point progress on the roadmap action as a whole.

Progress on company actions

Company data regarding its circular transition is sensitive and, industry-wide, data sets are currently not aligned or available. Until CEP members see value in communicating shared progress data through CEP, we leave reporting on individual progress to the companies.

Companies that are not yet preparing for the data exchange platforms being developed, and on a certain level becoming regulated, will need to start doing so. CEP recommends using existing industry frameworks for progress measurement, such as the Circular Transition Indicators (CTI v4.0). Developed by WBCSD, it is a simple objective and quantitative framework that can be applied at the company, business unit, facility or product (group) level.

Progress on wider stakeholder ask

While the CEP community has a clear view of topics addressed through the wider stakeholder ask, it would welcome engagement and conversation with that stakeholder landscape to further advance them. CEP will keep a close eye on developments within these actions; however, it recognizes it cannot take responsibility for the progress of these asks. Progress will therefore be reported on a case-by-case basis qualitatively rather than quantitatively.

Measuring the global circular transition

Progress on the CEP Roadmap enables us to understand if we are meeting our own objectives. However, the end goal of the partnership is to accelerate the global industry transition. Ultimately, CEP's work helps companies throughout the electronics value chain accelerate their individual circular transition. The success and impact of our work and industry transition can only be measured through macro-level data, for which we refer to reports like the Circularity Gap Report [36] and the Global E-waste Monitor.

Conclusion

In the past three years, the CEP Roadmap has proven itself to provide a valuable source of reference for the electronics industry and wider stakeholder landscape. Its comprehensive systemic approach to what is needed for circular transformation has been widely appreciated. Keeping the actions clear, accurate and up to date is essential to continue guiding the industry and its stakeholders on how they can contribute to the circular electronics vision.

None of the actions can be achieved by a single stakeholder category

While the roadmap is structured around six Pathways, no action can be achieved by a single category of players. Cooperation between value chain players and other stakeholders, such as public authorities, research organizations and academia, financial institutions, social enterprises, media and consumers, will be key to executing the roadmap.

Individual groups can function as catalysts. For example, defining best practices for data sanitization could be an action led by manufacturers in collaboration with users; translating this best practice into policy will require action by public authorities.

Continuing developing shared understanding and clear definitions remains key for all actions

While the concept of a circular economy is not new, developing a circular electronic product or service is not a simple process. In just a few years, we have come a long way in developing a shared, cross-value chain vision for what a circular electronics industry could look like in the CEP Circular Electronics System Map: An Industry Blueprint for Action.[37] This agreed understanding, among some of the industry's biggest and most circular-advanced companies across the value chain, articulates the criteria for a circular product – as well as a path towards industry transformation. On a circularity measurement level, frameworks like the Circular Transition Indicators (CTI) are developing, with a specific guide for the electronics sector to be expected soon.

Further establishing a common language will facilitate increased cooperation between value chain partners and key stakeholders. As with the sustainable agri-food sector (e.g., organic certification) or clean energy sector (e.g., guarantee of origins for green electricity), measurable and verifiable criteria are needed to effectively market circular products and services. The same applies to high-quality secondary materials with assurance to material performance and EHS practices.

Strengthening and expanding existing processes will also support the transition

Changing the existing system requires publicly financed incentives for the private sector, which could include encouraging private investment in waste processing capacities or for secondary material procurement. Without public support, a "coalition of the willing" will not have the power or capacity to sustain change with long-term benefits for society at large.

In addition to direct or indirect economic support, private-public sector collaboration can ensure effective and outcome-oriented policies. This includes accounting practices that favor circular solutions, accelerated PIC processes for responsible transboundary movement with circular objectives, the implementation and enforcement of labor rights and the development of effective EPR regulation that encourages the right actions by all stakeholders.

Circular electronics is a key contributor to the UN SDGs

The tech industry is uniquely positioned to raise awareness of circularity and make it tangible for people around the globe. Nearly everyone is connected to an ICT device reflecting the opportunity, but also the responsibility, the tech sector faces. It has the potential to significantly contribute to the UN SDGs and enhance people's lives, but it also needs to ensure responsible action along the whole value chain. Incorporating circular thinking and value into electronic products and services allows companies to responsibly maintain the growing prominence of technology while enabling society to remain resilient, innovative and sustainable.

This updated roadmap can support the industry and its stakeholders to identify and implement the concrete actions needed to enable a circular transition. The CEP facilitates much-needed collaboration among key stakeholders and helps track progress to realize the vision behind each identified Pathway.

Annex

Glossary

Business model	A business model describes how a company creates, delivers and captures value. It is described through the value proposition, resource requirements, cost structure, revenue streams, activities, customer segments, communication channels and partners.
Circular economy	A circular economy is an economic model that is restorative and regenerative by design, and aims to keep products, components and materials at their highest utility and value while minimizing raw materials input into the value chain and reducing waste streams.
Circular electronics	In line with common measurement frameworks for circularity, circular electronic products are defined by three key attributes: 1. they are made from verified circular resources; 2. they were designed for use-phase optimization and material recovery; and 3. they are in fact used based on circular principles and actually recovered at end of life [based on CEP's Circular Electronics System Map].
Circular Electronics Partnership (CEP)	The CEP is a coordination platform for its partners, industry members and the wider stakeholder network, driving collective and converging action on global initiatives for circular electronics. See the introduction for further details.
Circular product design	Incorporating elements in the design stage of a product with the aim of enabling a circular economy. These elements include, but are not limited to, designing for reusability, recyclability, upgradability, durability, modularity, repairability, as well as the energy and water efficiency of a product, product parts, components and materials. Also referred to as "design for circularity" in this report [based on ITU-T L.1023].
Collection	Both formal and informal collections are grouped together in this report. This is separate from take-back services conducted by businesses whose operation is to supply, purchase, sell or lease EEE. Collection is the act of collecting something from a place or from people.
Consumer	This includes individuals and households, but also bulk consumers such as public and commercial users of EEE. A person or entity who purchases goods and services for personal use.
Digital Product Passport (DPP)	A DPP is a structured collection of product related data with pre-defined scope and agreed data ownership and access rights conveyed through a unique identifier and that is accessible via electronic means through a data carrier. The intended scope of the DPP, proposed by the European Commission, is information related to sustainability, circularity, value retention for reuse, remanufacturing, and recycling [definition by CIRPASS].
Electronic products	All types of electronic and electrical equipment as defined by the EU WEEE Directive 2012/19/ EU. This includes devices and equipment from six product categories: temperature exchange equipment, screens and monitors, lamps, large equipment, small equipment and small IT.
Electronics manufacturer	A business manufacturing electronic products, including original equipment manufacturers. Manufacturers can also be producers if they sell or lease directly to consumers.
E-waste	Waste generated from discarded electronics that can no longer be repaired for reuse. Products and components that are labeled as WEEE but destined for reuse are not at the end of their life and hence not considered e-waste.

Extended producer responsibility (EPR)	Policy principle to promote total life cycle environmental improvements of product systems by extending the responsibility of the manufacturers of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling and final disposal of the product [ITU-T L.1021].
Informal economy	Informal system that operates without clear regulation or quality control and outside the guidelines of governmental authority, labor standards or taxation.
Prior Informed Consent (PIC) procedure	Under the Basel Convention, transboundary movements of hazardous wastes and other notifiable wastes must follow a PIC notification process in which the competent authority in the state of export is to provide a notification to the competent authorities of the State of import and any State of transit. The State of import shall respond to the notifier, e.g., consenting the movement, and a State of transit may provide written or tacit consent.
Producer	Anyone who places electrical and electronic equipment (EEE) on the national market of a country. This includes legal entities that manufacture EEE or have EEE manufactured and sell it within the country, resell EEE within the country or import EEE into the country.
Raw material	A basic material that can be used to produce components, finished products or intermediate materials. A raw material can result from primary or secondary resources.
Recycled content	Percentage of secondary materials within a raw material, component or product.
Repurposing	Repurposing includes reuse of products and components through repair, reprocessing, refurbishment, remanufacturing or parts harvesting, and the high-quality recycling of materials where reuse is not a viable option.
Return	Determined by availability and accessibility of facilities, this term is used mainly in reference to individuals or households who return used or end-of-primary-life EEE to a drop-off point or to an equipment manufacturer or supplier of EEE, either with or without financial incentives.
Reuse	Used as a broader term in this report to summarize the reuse of products and components through repair, refurbishment, remanufacturing, reprocessing or parts harvesting.
Reverse supply chain	The process whereby products that are dispossessed by the consumer are collected and moved to a place where they can be efficiently and safely reused or recycled.
Sourcing	Procurement of products, components or raw materials (whether virgin or secondary materials).
Stakeholder	Any actor, institution, group or individual – public or private – with an interest or a role to play in a societal, economic or environmental decision-making process.
Take-back	The return of electronic products that have reached the end-of-primary-life cycle in their original form and are incapable of performing their original intended function or that their purchaser or consumers no longer need (B2C, B2B and B2G). Its purpose is to maintain the life-cycle value of EEE through reuse, repair, reprocessing, remanufacturing or refurbishment or, as a last resort, through safe and efficient environmental management.
Traceability	The ability to identify, track and trace elements of a product or substance as it moves along the life cycle, from raw materials to finished products and applications and the other way around.
Waste Electrical and Electronic Equipment (WEEE)	A term used to cover all EEE that has reached the end of its primary life in its original manufactured form. WEEE is incapable of performing its original intended function but is not technically waste, rather an asset or resource in the context of a circular economy. But WEEE is used in this report as a common term understood by the global community (see also the definition for electronic products).

List of acronyms

Acronym	Meaning
B2B	Business-to-Business
B2C	Business-to-Consumer
B2G	Business-to-Government
BMZ	German Ministry of Economic Cooperation and Development
CDP	formerly Carbon Disclosure Project
CDSB	Climate Disclosure Standards Board
CEP	Circular Electronics Partnership
CTI	Circular Transition Indicators
DPP	Digital Product Passport
EEE	Electrical and Electronic Equipment
EHS	Environment, Health, Safety
EPEAT	Electronic Product Environmental Assessment Tool
EPR	Extended Producer Responsibility
ESG	Environmental, Social, Governance
EC	European Commission
EU	European Union
GAAP	Generally Accepted Accounting Principles
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
HS	Harmonized System
ICT	Information and Communications Technology
IFRS	International Financial Reporting Standards
IIRC	International Integrated Reporting Council

Acronym	Meaning
ISO	International Organization for Standardization
ISWA	International Solid Waste Association
IT	Information Technology
ITU	International Telecommunication Union
NGO	Non-Governmental Organization
OECD	Organization for Economic Co-operation and Development
P1, P2, etc.	Pathway
PAHs	Polycyclic Aromatic Hydrocarbons
PCPs	Polychlorinated Biphenyls
PIC	Prior Informed Consent Regulation
SASB	Sustainability Accounting Standards Board
SDGs	Sustainable Development Goals
TCO	Certification by Swedish Confederation of Professional Employees
UN	United Nations
UNEP	UN Environment Program
UNU	UN University
USD	US Dollar
VAT	Value Added Tax
WBCSD	World Business Council for Sustainable Development
WEEE	Waste Electrical and Electronic Equipment
WHO	World Health Organization

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ERM
Glencore U.S.
Global Electronics Council (GEC)
Global Enabling Sustainability Initiative (GeSI)
Global Resale, Ltd
Globant
Globe Telecom
Google
Grover
GSMA
Hewlett Packard Enterprise
HP Inc.
Huawei
iNEMI
International Telecommunication Union
Iron Mountain
Jabil
Karo Sambhav Private Limited
Kingfa Sci. and Tech. Co.
KPMG
Lenovo
Microsoft
NamiGreen
Nokia
Philips
Platform for Accelerating the Circular Economy (PACE)
Responsible Business Alliance (RBA)
Safaricom
Seagate Technology
Security Matters
Sims Lifecycle Services
Solving the e-Waste Problem (StEP)
TES
Umicore Precious Metals Refining
Veolia
Virgin Media O2
Whirlpool EMEA spa
World Business Council for Sustainable Development (WBCSD)
World Economic Forum (WEF)
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