circular electronics partnership

Circular Electronics Roadmap:

An Industry Strategy Towards Circularity

Introduction of the CEP

The Circular Electronics Partnership (CEP) drives a coordinated transition towards an economically viable circular industry. It strives to maximize the value of products, components and materials throughout the full life cycle, using safe and fair labor and depending only on circular resources.

This vision has been described in detail in the CEP Vision Statement.[1] This document is a roadmap to help the electronics industry and its stakeholders to transition to circular electronics.

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 specifically includes devices and equipment from six product categories: temperature exchange equipment, screens and monitors, lamps, large equipment, small equipment, and small IT.[2] From a market perspective, circular electronics include B2C and B2B equipment sold in bulk and in individual units.

Partners

Global Electronics Council — Sustainability for a Connected Future

GeSI — Enabling Digital Sustainability

PACE — Platform for Accelerating the Circular Economy

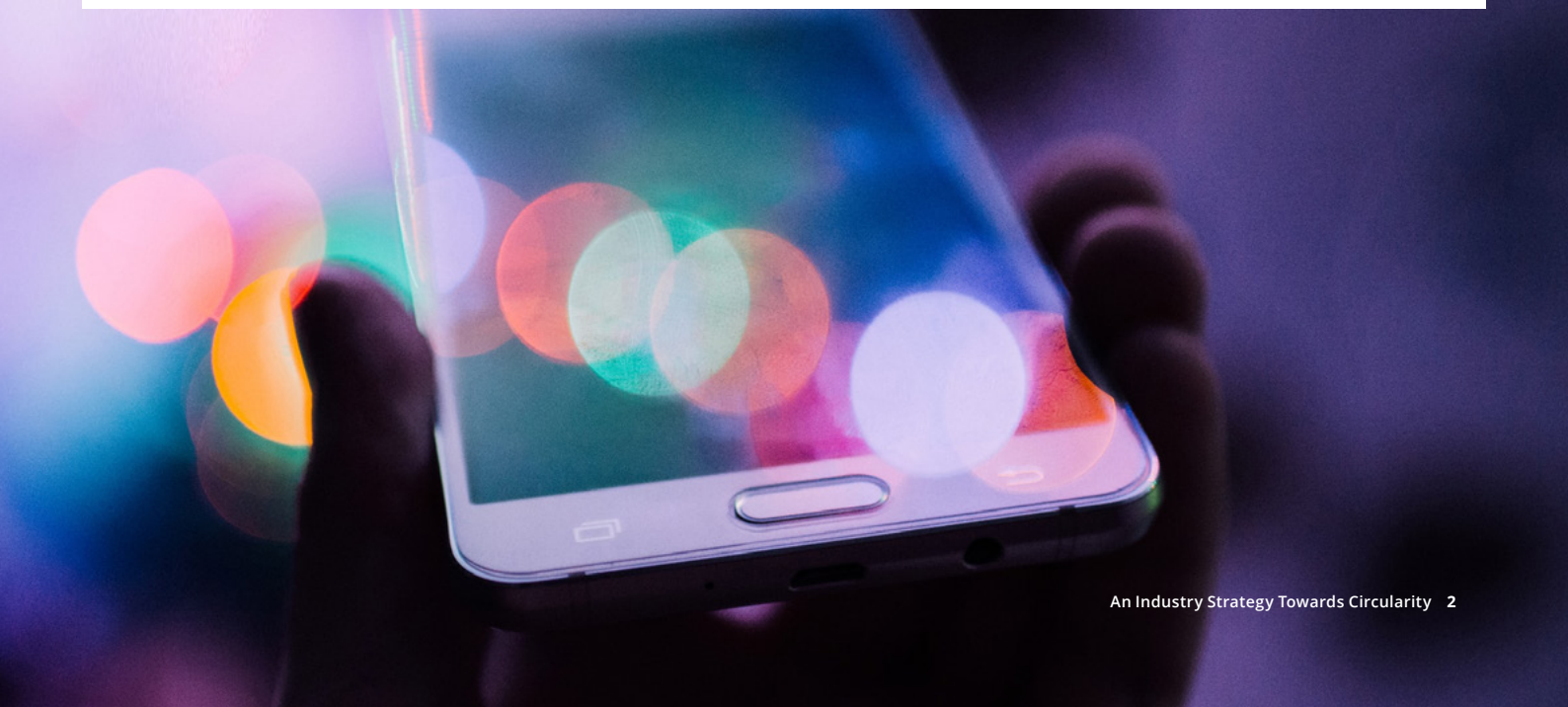
Responsible Business Alliance — Advancing Sustainability Globally

wbcsd

World Economic Forum

Supported by: **Accenture**

In collaboration with: ITU



List of Acronyms

Acronyms	Meaning
B2B	Business-to-Business
B2C	Business-to-Consumer
B2G	Business-to-Government
CAGR	Compound Annual Growth Rate
CDP	Carbon Disclosure Project
CDSB	Climate Disclosure Standards Board
CENELEC	Committee for Electrotechnical Standardization
CEP	Circular Electronics Partnership
CTI	Circular Transition Indicators
EEE	Electrical and Electronic Equipment
EHS	Environment, Health, Safety
EPEAT	Electronic Product Environmental Assessment Tool
EPR	Extended Producer Responsibility
ESG	Environmental, Social, Governance
EU	European Union
GAAP	Generally Accepted Accounting Principles
GRI	Global Reporting Initiative
ICT	Information and Communication Technologies
IFRS	International Financial Reporting Standards
IIRC	International Integrated Reporting Council
IT	Information Technology
ITU	International Telecommunication Union

Acronyms	Meaning
NGO	Non-Governmental Organizations
OECD	Organization for Economic Co-Operation and Development
OEM	Original Equipment Manufacturer
P1, P2, ...	Pathway
PACE	Platform for Accelerating the Circular Economy
PAHs	Polycyclic Aromatic Hydrocarbons
PCPs	Polychlorinated Biphenyls
PIC	Prior Informed Consent Regulation
SASB	Sustainability Accounting Standards Board
SDGs	Sustainable Development Goals
SDO	Social Development Organization
TCO	Certification by Swedish Confederation of Professional Employees
UN	United Nations
USD	US Dollar
VAT	Value Added Tax
WBCSD	World Business Council for Sustainable Development
WEEE	Waste Electrical and Electronic Equipment

The Need for Action

Linear value chains create sourcing pressure and generate more than 50 million tons of e-waste each year

While e-waste is the fastest growing waste stream in the world,[3] its disposal is currently not well managed. To date, e-waste represents 2% of solid waste streams but 70% of hazardous waste that ends up in landfill.[4,5]

The growth trend for electronics is continuing with drivers such as electronics becoming more affordable in developing economies, the increased embeddedness of electronics in traditionally non-electronic goods and the propagation of electronics in everyday life (e.g. also related to COVID-19). Without corrective action, a further acceleration of natural resource consumption and e-waste generation can be expected.

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

While soil and water contamination are known environmental issues, the global sanitary impacts of e-waste have not been fully quantified yet. However, examples show that there are clear health impacts on populations involved in improper informal e-waste recycling, such as skin diseases, adverse effects on birth outcomes, cardiovascular effects, and altered neurodevelopment or adverse learning outcomes.[6] In India, for example, it is estimated that over one million people involved in informal, manual recycling are exposed to hazardous substances (heavy metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), brominated flame retardants).[7]

The economic value at stake for industry players is not only in recycling

The value of total raw materials in global e-waste is approximately $57 billion USD mainly coming from iron, copper and gold.[8] High-quality recycling of valuable materials from information and communications technology (ICT) devices alone is estimated to present a $2.5–$5 billion USD opportunity.[9] In 2019, at a collection rate of 17.4% only $10 billion USD were recovered from global e-waste.[10] However, an even bigger opportunity lies in circular services and products, such as in reuse and refurbishment. For ICT devices, this opportunity is estimated at $10-$20 billion USD. Circular design principles can also cost effectively extend the life of a product. An analysis on routers found that certain design choices (e.g. using scratch-resistant materials) can reduce refurbishment costs by about 50%.[11]

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 their willingness to act early in embracing circularity, can ultimately be better positioned in tomorrow's market. Beyond the private sector, the collective transition towards a circular electronics industry will require partnership with the public sector and civil society. In a post-COVID-19 world, governments may choose to restart struggling economies as circular economies.

Now is the time for coordinated action at scale. This Roadmap is designed to guide how the electronics value chain and its key stakeholders can make circular electronics the new normal.

A Roadmap Towards a Circular Electronics Industry

Overview

In 2020, the Circular Electronics Partnership (CEP) launched an extensive stakeholder engagement process, mobilizing more than 80 experts from 40 companies and the six founding partners. Throughout the year, experts from companies, industry associations and non-governmental organizations (NGOs) have collaborated in six working groups, also referred to as the six CEP Pathways, over a six-month period. The Circular Electronics Roadmap identifies the barriers, enablers, interventions and asks identified in these collaborative Pathway sessions. In addition, it draws insights from the Action Agenda for circular electronics presented by the Platform for Accelerating the Circular Economy (PACE), one of the founding partners of CEP.

The CEP Roadmap is structured around the six Pathways and their objectives to drive progress in key stages of the electronics value chain. Combining the actions defined across the Pathways presents a comprehensive picture of what is needed to drive system transformation towards the vision of a more circular electronics industry. Figure 1 below illustrates the industry Roadmap towards circularity across all six Pathways.

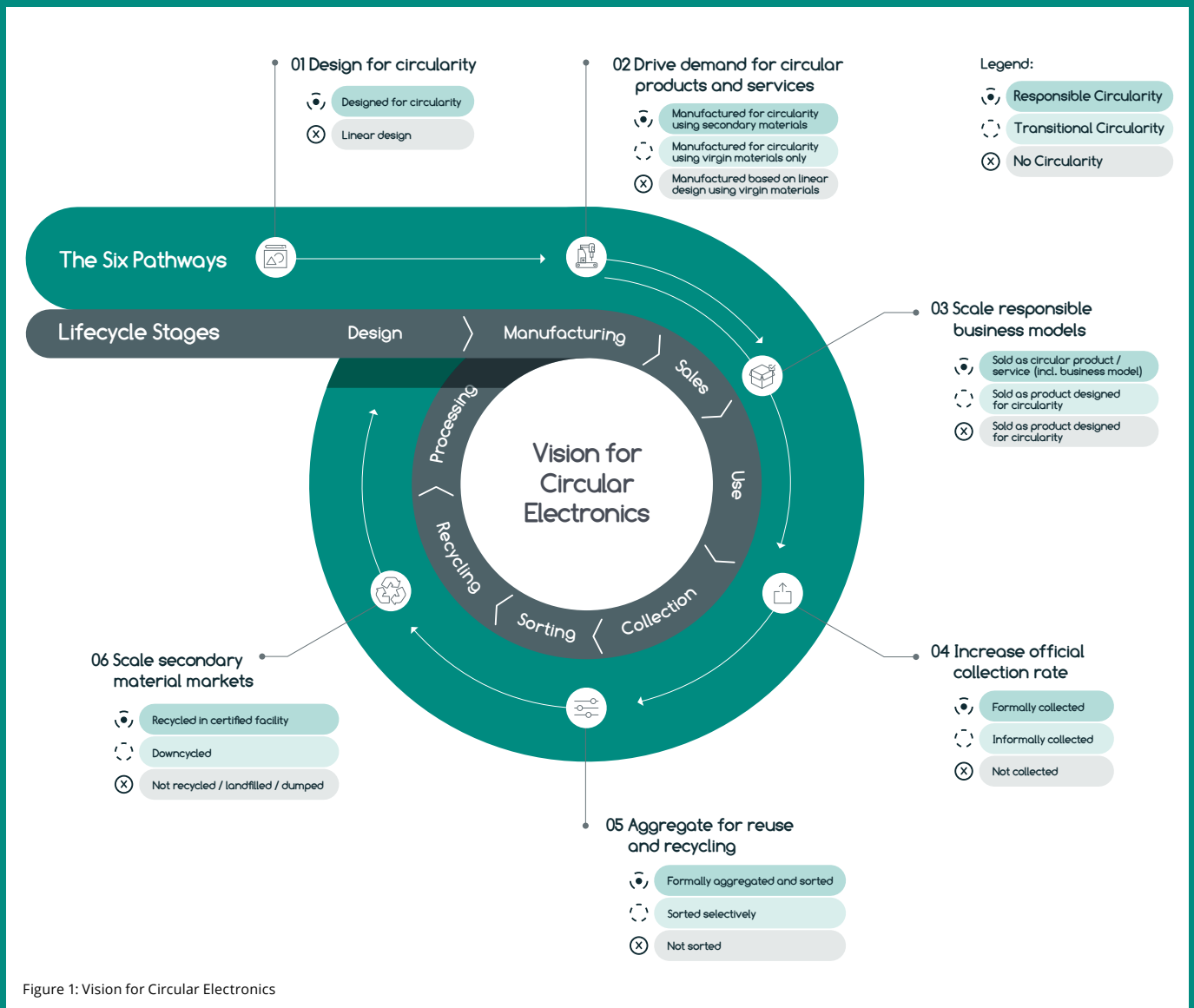


Figure 1: Vision for Circular Electronics

Our Roadmap

In the Roadmap, actions are divided into three types (See Figure 2):

- interventions that can be led by industry players, i.e. companies (purple);
- interventions that require the joint leadership of industry players and partners (pink); and
- asks to governments, NGOs and research organizations (grey).

The timeline indicates when each action should be implemented and scaled by.

All actions will be described in detail in the following chapters of this Roadmap, highlighting proposed main actors and supporters. Some actions are highly interlinked, enabling other actions or mutually enforcing each other. Therefore, the most relevant pre-requisite actions and interdependencies are emphasized as part of all action descriptions.

Explore the six pathways of our roadmap

CEP aims to achieve the following initiatives by...

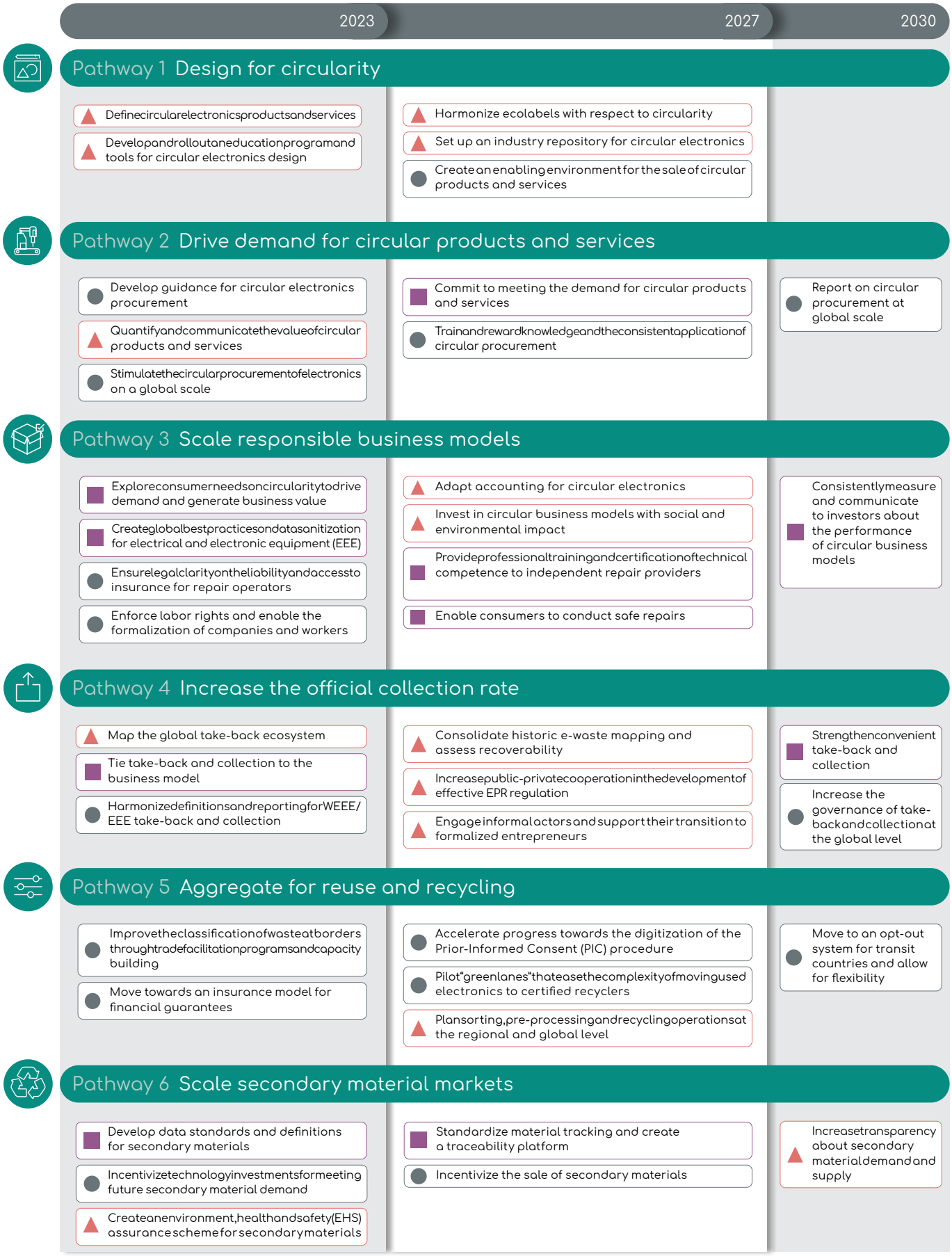


Figure 2: Explore the six pathways of our roadmap

Pathway 1: Design for circularity

Product design for circularity plays a crucial role in enabling a circular economy for electronic devices and equipment. Designing for dematerialization, longevity, reuse and recyclability and adopting specifications for sustainable materials and components provide great opportunities to optimize value generation at each stage of a product's life cycle.

The key barriers to circularity at this stage of the value chain include:

- a lack of industry-wide standards and definitions for circular electronics products and services;
- a lack of transparency and need for further evolution of ecolabels;
- limitations in the mandate for circular product design from company leadership;
- a lack of demand for circular electronics products and services;
- a lack of collaboration between stakeholders engaged in product development and life cycle partners;
- insufficient actionable training for designers and engineers; and
- limited accessibility of best practices and case studies for circular product design at scale.

As product design is highly interlinked with subsequent stages of the value chain, several barriers and actions discussed within other Pathways are highly relevant for progress to design for circularity.

The following actions have been prioritized for driving responsible circularity through designing for circularity:

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

Main actors:	Electronics manufacturers, standards organizations, NGOs
Supporters:	Recyclers, other producers, governments
Pre-requisite actions:	–
Depending and interdependent actions:	**P1.2:** Harmonize ecolabels with respect to circularity
	P2.1: Develop guidance for circular electronics procurement
	P1.4: Create an enabling environment for the sale of circular products and services
	P6.1: Develop data standards and definitions for secondary materials

International standards are crucial for establishing a common vocabulary for implementing and evaluating circular economy. Standards are also needed to drive harmonization efforts in related government policies, procurement practices and certification schemes, bringing consistency across the sector to achieve circularity-related goals. Currently, standards are being developed that cover many of the key aspects to design, including recycled content or recyclability (e.g. by the European Committee for Electrotechnical Standardization, International Telecommunication Union). Electronics manufacturers can work with standardization institutions to develop an industry-wide standard for what constitutes a circular product and service and how to assess it – incorporating the product design and the business model perspective. Recyclers, importers, resellers and relevant public sector entities need to contribute to this process. This definition should consider the context and associated characteristics of different categories of electronics and the design requirements for each.

P1.2 – Harmonize ecolabels with respect to circularity

Main actors:	Electronics manufacturers, standards organizations
Supporters:	Recyclers, governments, NGOs
Pre-requisite actions:	P1.1: Define circular electronics products and services
	P6.1: Develop data standards and definitions for secondary materials
Depending and interdependent actions:	P2.1: Develop guidance for circular electronics procurement
	P2.4: Commit to meeting the demand for circular products and services

Certification schemes and ecolabels serve as an opportunity for companies to demonstrate compliance with circular product design requirements and standards to consumers. The barrier to their adoption: A confusing number of ecolabels, many issued on a national or regional level, with differing standards for what constitutes circularity. Electronics manufacturers can cooperate with ecolabel providers to harmonize circularity criteria in the relevant ecolabels for the electronics industry (e.g. EPEAT, Blue Angel, Energy Star, Cradle to Cradle, TCO certified).

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

Main actors:	Industry associations, academia
Supporters:	NGOs, electronics manufacturers, recyclers, governments
Pre-requisite actions:	**P1.1:** Define circular electronics products and services
	P6.1: Develop data standards and definitions for secondary materials
Depending and interdependent actions:	–

In the product development phase, designers and other stakeholders engaged in it are required to balance a range of different requirements including design for circularity (e.g. repairability, recyclability, use of recycled content), product safety (e.g. inflammability), customer preferences (e.g. usability) and economic requirements (e.g. production cost). It is critical then to provide designers and product developers with the right 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, industry associations can cooperate with NGOs and universities to develop tools and training for designers and engineers. The education program can be rolled out as corporate training program for professionals, and as part of relevant study programs at universities.

P1.4 – Create an enabling environment for the sale of circular products and services

Main actors:	Governments
Supporters:	Industry associations
Pre-requisite actions:	**P1.1:** Define circular products and services
	P6.1: Develop data standards and definitions for secondary materials
Depending and interdependent actions:	**P5:** All actions
	P6.6: Incentivize the sale of secondary materials

Demand for circular products and services is the main driver for the development of circular products and services and critical for making it 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. Efforts have been made in this space (e.g. EU WEEE Directive). But up to now, policies have shown limited effectiveness. This is likely due to policies focusing just on waste reduction rather than taking a view of the full value chain. Building on the momentum of the EU Green Deal and the new Circular Economy Action plan, governments need to develop and implement policy measures that incentivize the development and uptake of circular products and services, while not over-regulating the detailed execution. This includes value-added tax reductions, extended warranty periods, or modulated Extended Producer Responsibility (EPR) fees. Additional actions for driving demand for circular products and services, especially through organizational procurement, are examined in Pathway 2. Pathway 5 looks at how transaction costs for reverse logistics, which play a key role in a circular economy for electronics, can be reduced.

P1.5 – Set up an industry repository for circular electronics

Main actors:	NGOs, industry associations
Supporters:	Standards organizations, electronics manufacturers
Pre-requisite actions:	–
Depending and interdependent actions:	–

To further accelerate circular product design practices, an NGO or industry association can set up an online repository of circular design materials. This can include standards references and definitions on circular electronics products and services, eco-design policies and regulation for different regions, best practices of design for circularity in the industry, case studies, etc. The database can help encourage and enable designers, marketers, distributors and other relevant actors to prioritize circular design criteria in their products by providing them with information on available circular tools in an accessible manner.

Pathway 2: Drive demand for circular products and services

Public and private sector procurement (business-to-business (B2B), business-to-government (B2G) are key levers for creating demand for circular products and solutions, and creating a market incentive for manufacturers to scale existing circular solutions and business models and innovate in entirely new ways.

There are some early activities, such as public requests for proposals, there are still many barriers that need to be addressed.

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

- lack of understanding of circularity, its benefits and how circular procurement differs from and complements existing sustainable procurement requirements;
- lack of integration of circular requirements into organizational procurement guidelines;
- lack of organizational commitment to circular procurement;
- lack of industry-wide commitment to selling circular products and services;
- false beliefs about inferior performance, data security, warranty limitations and a "new is best" attitude;
- missing tools to quantify the benefits of circular procurement (and complexity to develop these);
- lack of integration into global environmental, social and governance (ESG) reporting metrics; and
- lack of training for procurement professionals.

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

P2.1 – Develop guidance for circular electronics procurement

Main actors:	NGOs, academia, standards organizations
Supporters:	Industry associations, public and private sector procurement, governments
Pre-requisite actions:	**P1.1:** Define circular electronics products and services
	P6.1: Develop data standards and definitions for secondary materials
Depending and interdependent actions:	**P2.2:** Stimulate the circular procurement of electronics on a global scale
	P2.4: Commit to meeting the demand for circular products and services
	P2.5: Train and reward knowledge and the consistent application of circular procurement
	P2.6: Report on circular procurement on a global scale

Integrating circularity criteria into organizational procurement processes can drive major purchasers of electronics products and services towards increased circularity and influence overall market demand. NGOs, academia 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 the procurement processes of their organizations and reconsider specifications that prevent circularity (e.g. specifications that only allow tendering of new devices and equipment). Waste management guidelines can also play a critical role for circular procurement and should be revised to avoid linear practices (e.g. demand destruction, prohibit reuse, prohibit take-back).

P2.2 – Stimulate the circular the procurement of electronics on a global scale

Main actors:	Governments, public and private sector procurement
Supporters:	Industry associations, NGOs
Pre-requisite actions:	**P2.1:** Develop guidance for circular electronics procurement
	P2.4: Commit to meeting the demand for circular products and services
Depending and interdependent actions:	**P2.5:** Train and reward knowledge and the consistent application of circular procurement

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. In addition, commitments provide direction to employees within an organization and create a sense of urgency for 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 a defined annual percentage spend on circular information technology (IT) products and services and 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 the continuity of supply chain, climate resiliency and in upcoming policies (e.g. the EU Green Deal).

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

Main actors:	NGOs, industry associations, researchers, academia
Supporters:	Electronics manufacturers, importers, resellers, governments
Pre-requisite actions:	**P1.1:** Define circular electronics products and services
Depending and interdependent actions:	**P2.2:** Stimulate the circular procurement of electronics on a global scaleprocurement

Fact-based communication about the social, environmental and economic benefits of circular procurement helps to raise awareness for circular products and services and creates a sense of urgency for changing status quo thinking from linear to circular.

NGOs, industry associations, manufacturers, resellers and governments could raise awareness through campaigns to educate purchasers and individual consumers on the benefits of circular electronics products and services, while also raising awareness of the environmental, social and health impact of electronics in a linear economy. NGOs, with the support of research organizations, can develop tools that help to quantify the environmental, social and economic benefits of circular products and services, highlighting the value case and associated organizational benefits for buyers. Increased awareness among consumers supports the uptake of organizational and governmental policies that stimulate circular electronics.

P2.4 – Commit to meeting the demand for circular products and services

Main actors:	Electronics manufacturers, importers and resellers
Supporters:	Industry associations, NGOs
Pre-requisite actions:	**P1.1:** Define circular electronics products and services
	P6.1: Develop data standards and definitions for secondary materials
	P6.2: Create an EHS assurance scheme for secondary materials
Depending and interdependent actions:	**P2.2:** Stimulate the circular procurement of electronics on a global scale
	P3.4: Invest in circular business models with social and environmental impact

A clear commitment to circular electronics from producers, especially manufacturers, is needed to signal to the demand side of the market that there will be a wide range of products and services available that meet circular procurement requirements. Producers can integrate circularity into their corporate strategies, adopt circular design and sourcing policies, and partner with their 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 support producers' commitments with a global campaign engaging producers to commit to circularity and meet purchasers' demand for circular electronics.

P2.5 – Train and reward knowledge and the consistent application of circular procurement

Main actors:	NGOs, industry associations, electronics manufacturers
Supporters:	Public and private sector procurement
Pre-requisite actions:	**P2.1:** Develop guidance for circular electronics procurement
Depending and interdependent actions:	**P2.2:** Stimulate the circular procurement of electronics on a global scale

Training and knowledge sharing can support purchasers in integrating guidance on circular electronics procurement into their own organizational processes, such as category management, process improvement and demand management. NGOs, industry associations and manufacturers can offer training to 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, thereby incentivizing the wider uptake of circular electronics procurement.

P2.6 – Report on circular procurement on a global scale

Main actors:	Public and private sector procurement, ESG reporting organizations
Supporters:	–
Pre-requisite actions:	**P2.1:** Develop guidance for circular electronics procurement
Depending and interdependent actions:	**P2.2:** Stimulate the circular procurement of electronics on a global scale
	P2.5: Train and reward knowledge and the consistent application of circular procurement

ESG reporting has become increasingly relevant to investment decisions. In 2018, ESG factors were systematically included in financial analysis on $17.5 billion USD worth of investing assests, an increase of 30% compared to 2016.[12] Circularity in sourcing of raw materials and procurement of products and services is currently not integrated into existing ESG reporting guidelines, leading to a lack of global reporting on the issue. The integration of circular sourcing and procurement in ESG accounting standards (e.g. GRI, SASB) and protocols by ESG reporting organizations (e.g. CDP) could lead to more informed and targeted investment. To support this process, consideration could be given to initiatives, such as the collaboration between CDP, CDSB, GRI, IIRC and SASB announced last September,[13] and existing guidance or policies on non-financial reporting (e.g. Disclosure and Engagement Guidance to Accelerate Sustainable Finance for a Circular Economy in Japan).[14]

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 and 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 such as product use extension, sharing platforms and product-as-a-service.[15]

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 of financing;
- limited access to repair and refurbishment for consumers;
- lack of simple and safe data sanitization options; and
- lack of harmonized supply chain due diligence requirements across different international and national procurement frameworks.

The need to strengthen demand for circular electronics products and services as a driver for circular business models is an additional key aspect that has been covered in detail in the previous section.

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

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

Main actors:	Electronics manufacturers, retailers
Supporters:	Academia
Pre-requisite actions:	–
Depending and interdependent actions:	**P1.3:** Develop and roll out an education program and tools for circular electronics design
	P2.3: Quantify and communicate the value of circular products and services

Enhancing current and developing new value propositions of circular products and services is key to driving demand and ensuring circular business models offer business value. The key will be to center this development around consumer needs. 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. Also, marketing teams will require training on how to drive the appeal and position of such products and services in the market, with consideration of the substantiation of green claims.

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

Main actors:	Electronics manufacturers, importers and resellers, additional providers of circular services
Supporters:	Financial institutions
Pre-requisite actions:	**P1.1:** Define circular electronics products and services
Depending and interdependent actions:	**P3.4:** Invest in circular business models with social and environmental impact

To support the transition to a circular electronics industry, investors will need to adapt their understanding of value creation, risk and short-term versus long-term profits. It is the task of producers to consistently measure and communicate to investors about circular performance of products and services, and to demonstrate 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 the associated financial performance with metrics such as percentage of revenue and profits from responsible circular offerings. In addition, highlighting the establishment of public-private partnerships can encourage and mitigate risk associated with investment in new business models and technologies.

P3.3 – Adapt accounting for circular electronics

Main actors:	Governments, industry associations
Supporters:	Accountants, business consultants
Pre-requisite actions:	–
Depending and interdependent actions:	**P2.2:** Stimulate the circular procurement of electronics on a global scale
	P3.4: Invest in circular business models with social and environmental impact

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 an 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. Also, they can 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, e.g. including guidance for estimating residual values of assets or for sizing the cost of repair and refurbishment.

P3.4 – Invest in circular business models with social and environmental impact

Main actors:	Electronics manufactures, importers and resellers, other service providers, financial institutions
Supporters:	Social enterprises
Pre-requisite actions:	**P3.2:** Consistently measure and communicate to investors about the performance of circular business models
	P3.3: Adapt accounting for circular electronics
Depending and interdependent actions:	**P2.4:** Commit to meeting the demand for circular products and services
	P4.8: Tie take-back and collection to the business model

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 prioritizing 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 to drive demand (see Pathway 2). Financial institutions need to act responsibly and increase financing options for circular business models, e.g. by holistically integrating circularity and human rights in the assessment of financial and ESG performance.

P3.5 – Create global best practices on data sanitization

Main actors:	Electronics manufacturers, governments
Supporters:	Independent repair providers, standards organizations, industry associations
Pre-requisite actions:	–
Depending and interdependent actions:	–

Reuse, refurbishment, remanufacturing and high-value material recycling depends on the timely take-back of unused electronic devices and e-waste. Simple, safe data sanitization solutions are needed to mitigate fears surrounding data misuse and insecurity around safe data sanitization options that disincentivize consumers to return unused devices and motivate some organizational purchasers to demand the destruction of used devices and equipment. Electronics manufacturers can collaboratively develop a global best practice approach for integrating a safe data sanitization software in all electronics that store personal data. The user of the device or equipment should be enabled to perform the data sanitization themselves. Clear communication about the available data sanitization options can promote their use and reduce insecurities. Governments can collaborate with manufacturers on policies that drive progress in this area.

P3.6 – Ensure legal clarity on the liability for product defects and access to insurance for repair and refurbishment

Main actors:	Governments
Supporters:	Industry associations, electronics manufacturers, independent repair providers, insurance companies
Pre-requisite actions:	–
Depending and interdependent actions:	**P4.7:** Strengthen convenient take-back and collection

Repair providers play a key role in the circular economy, providing fast and straightforward product services to local customers. Professional refurbishment providers, including manufacturers, complement these services, often 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. 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 consumers. The European Commission's plans to establish a "right to repair" for electronics will require the definition of responsibilities.[16] 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 to address the issue. The "right to repair" legislation currently in place in some 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.

P3.7 – Provide professional training and certification of technical competence to independent repair providers

Main actors:	Electronics manufacturers
Supporters:	Electronics Importers and resellers
Pre-requisite actions:	**P3.6:** Ensure legal clarity on the liability for product defects and access to insurance for repair and refurbishment operators
Depending and interdependent actions:	–

Electronics manufacturers could support product use extension by partnering with independent repair and refurbishment providers. They could provide training and certification of technical competence to professionals that can most effectively provide access to repair and refurbishment services to the manufacturers' customers. Focusing on pre-competitive solutions, the development of an open-access catalogue that includes links to shops where common replacement parts and tools could be purchased by independent repair and refurbishment professionals.

P3.8 – Enable consumers to conduct safe repairs

Main actors:	Electronics manufacturers, importers and resellers
Supporters:	Governments
Pre-requisite actions:	**P3.6:** Ensure legal clarity on the liability for product defects and access to insurance for repair and refurbishment operators
Depending and interdependent actions:	–

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

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

Main actors:	Governments, electronics manufacturers, financial institutions, recyclers
Supporters:	Industry associations
Pre-requisite actions:	–
Depending and interdependent actions:	**P4.4:** Engage informal actors and support their transition to formalized entrepreneurs
	P6.2: Create an EHS assurance scheme for secondary materials

Informal repair providers, collectors and recyclers are dominating the electronics value chain in many emerging 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, including ensuring adequate and safe 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, which will 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.

Pathway 4:
Increase the official collection rate

Improving the take-back rate of electronics at the end of use is essential for achieving 100% responsible repurposing of sold EEE. Repurposing includes the reuse of products and components through repair, refurbishment, remanufacturing, re-use/ reprocessing or parts harvesting and the high-quality recycling of materials where 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 2019, the official global collection rate was 17.4% with strong regional variations.[17]

The key barriers to increased collection and responsible repurposing include:

- a lack of transparency throughout the global take-back ecosystem;
- a lack of formal take-back infrastructure in developing countries and emerging markets, connected to a lack of finance for this infrastructure;
- a lack of outcome-oriented policies or weak enforcement;
- a lack of global consistency in approach to policies and reporting; and
- inconvenience and a lack of incentives to encourage consumers to properly return electronics.

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

P4.1 – Map the global take-back ecosystem

Main actors:	Research organizations and academia
Supporters:	Producers, governments
Pre-requisite actions:	–
Depending and interdependent actions:	**P4.2:** Harmonize definitions and reporting for WEEE/EEE take-back and collection
	P4.4: Engage informal actors and support their transition to formalized entrepreneurs
	P4.7: Strengthen convenient take-back and collection
	P4.8: Tie take-back and collection to the business model

Scaling up the understanding of the global take-back ecosystem, which currently is not well-defined and managed, is necessary to prioritize gaps, define new interventions that advance take-back and drive the harmonization of reporting and regulation. For this, the informal and formal sector need to be considered.

Research organizations, with wide support from producers, recyclers and governments, can build on existing work and drive the assessment of take-back and collection activities around the globe. The analysis should focus on evaluating material flows by product category and on identifying relevant differences in national or regional take-back systems, both from a regulation and implementation/ enforcement perspective. The aim is to address barriers to change and identify and prioritize where action is needed most. Interventions in emerging markets, where the informal economy is dominating collection and e-waste management, could deliver the greatest economic, environmental and social benefits and should be a research priority. Here, transparency and data is currently very limited and might be hard to obtain.

P4.2 – Harmonize definitions and reporting for WEEE/EEE take-back and collection

Main actors:	Research organizations and academia, international organizations
Supporters:	Governments
Pre-requisite actions:	**P4.1:** Map the global take-back ecosystem
Depending and interdependent actions:	**P4.5:** Increase the governance of take-back and collection at the global level

A first step towards harmonizing approaches to take-back and collection globally 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.

P4.3 – Increase public-private cooperation in the development of effective EPR regulation

Main actors:	Governments, industry associations, producers, recyclers
Supporters:	International organizations
Pre-requisite actions:	**P4.1:** Map the global take-back ecosystem
Depending and interdependent actions:	**P4.5:** Increase the governance of take-back and collection at the global level
	P4.7: Strengthen convenient take-back and collection
	P4.8: Tie take-back and collection to the business model

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

P4.4 – Engage informal actors and support their transition to formalized entrepreneurs

Main actors:	Governments, producers, recyclers
Supporters:	International organizations, NGOs, waste collection companies
Pre-requisite actions:	**P3.9:** Enforce labor rights and enable the formalization of companies and workers
Depending and interdependent actions:	**P4.8:** Strengthen convenient take-back and collection

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

These actions support the transition of informal actors to formalized entrepreneurs and 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 and availability to take-back for many more consumers. Certified recyclers, in collaboration with NGOs and international organizations, can expand current collection work and develop pilot projects that create business models for buying e-waste from informal collectors to ensure safe material processing.

P4.5 – Increase the governance of take-back and collection at the global level

Main actors:	International organizations, governments
Supporters:	Producers and producer responsibility organizations, recyclers
Pre-requisite actions:	**P4.1:** Map the global take-back ecosystem
Depending and interdependent actions:	**P4.2:** Harmonize definitions and reporting for WEEE/EEE take-back and collection
	P5: All actions

While EEE is global in nature and moves across borders, there is no globalized EPR harmonization to date, which means there is no take-back and collection system that encompasses the global ecosystem of EEE consumption and production. An international organization can take on more leadership to fill the need for greater governance at the global level. The leading entity can engage national governments, manufacturers and recyclers to define global best practice for take-back and collection to develop common EPR principles. This will drive alignment and convergence on the responsibilities imposed by EPR and lead to harmonization.

P4.6 – Consolidate historic e-waste mapping and assess recoverability

Main actors:	Producers, research & academia
Supporters:	Recyclers, governments, international organizations, NGOs
Pre-requisite actions:	-
Depending and interdependent actions:	-

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 or accumulated in large storage halls in the past decades. Producers, with the support of researchers, can consolidate data about historic e-waste to get a better picture about locations and volumes, and assess recoverability of historic waste. This will be used to develop regional strategies for efficiently recovering these resources.

P4.7 – Strengthen convenient take-back and collection

Main actors:	Producers, producer responsibility organizations, retailers
Supporters:	Governments, recyclers
Pre-requisite actions:	**P4.3:** Increase public-private cooperation in the development of effective EPR regulation
Depending and interdependent actions:	**P4.4:** Engage informal actors and support their transition to formalized entrepreneurs
	P4.8: Tie take-back and collection to the business model

The actual return of electronics that is not used anymore by consumers (B2B, B2C and B2G) is a critical factor in take-back and collection. In addition to data security concerns (see Pathway 3), a lack of clarity on responsibility for take-back of equipment, and financial costs or inconvenience associated with the return process limit collection rates. To address these issues, producers, in collaboration with local governments, can incentivize for consumers to return equipment through investing in more convenient drop-off locations and exploring ways to reward the right behavior. Better communication of EEE on specific take-back opportunities and embedding messaging about take-back opportunities into the customer journey can raise awareness. To improve take-back rates from large purchasers, producers can consider integrating buy-back agreements or product-as-a-service models into purchasing contracts. In emerging markets there needs to be a clear focus on implementing regulation and boosting convenient take-back and collection schemes (see P4.6 and 4.8).

P4.8 – Tie take-back and collection to the business model

Main actors:	Producers, retailers
Supporters:	NGOs
Pre-requisite actions:	–
Depending and interdependent actions:	**P3.4:** Invest in circular business models with social and environmental impact
	P4.7: Strengthen convenient take-back and collection

Integrating solutions for take-back and collection into the business model is an additional driver. 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 for integrating take-back and collection into their value propositions and invest in creating digital solutions to facilitate take-back (e.g. reverse vending machines, product passports, etc.).[18]

Pathway 5: Aggregate for reuse and recycling

A reverse supply chain moves end-of-use products from areas with a surplus of end-of-use electronics 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.

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 signed by 188 parties. Members of the Basel Convention have committed to control the 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 Regulation (PIC). PIC processes are administered by the 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 key barriers to responsible transboundary movement include:

- a lack of experience in applying the Basel Convention, in various countries;
- different views around the level of control for the trade of used EEE and WEEE that still persists despite the revision of Technical Guidelines in the Basel Convention. This revision aimed 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”;
- processes and procedures in the implementation of the Basel Convention; and
- illegal trading of WEEE and the continuation of illegal dumping in developing countries.

As a result, 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.[19]

The following actions have been prioritized for facilitating the aggregation of EEE or WEEE for reuse and/or recycling while ensuring the highest social and environmental standards in transboundary shipments and supporting the principles and commitments of the Basel Convention:

P5.1 – Improve the classification of waste at borders through trade facilitation programs and capacity building

Main actors:	Governments, international organizations
Supporters:	Logistics providers
Pre-requisite actions:	-
Depending and interdependent actions:	-

Collected electronics destined for repair, refurbishment or recycling are either categorized at the border as "non-waste", "waste" or "hazardous waste". Definitions are often interpreted (or misinterpreted) differently in different jurisdictions leading to uncertainty around the classification of waste. International organizations can collaborate with policymakers and custom officials in countries that are part of the global electronics value chain to 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 the harmonized commodity description and coding system for electrical and electronic waste that has been developed by the Basel Convention secretariat and the World Customs Organisation and will take effect in 2022. The pilot projects should also aim to increase capacity for identifying illegal shipments and collect insights on how the definitions are used in practice.[20]

P5.2 – Accelerate progress towards the digitization of the PIC procedure under the Basel Convention

Main actors:	Governments
Supporters:	Logistics providers, electronics manufacturers, recyclers, international organizations, technology consultants
Pre-requisite actions:	–
Depending and interdependent actions:	**P5.5:** Pilot "green lanes" that ease the complexity of moving waste electronics to certified recyclers

Currently, the administrative requirements for transboundary shipments are largely paper-based, requiring original notification documents to be signed in hardcopy and posted to competent authorities in the importing, exporting and transit countries for approval. To reduce transaction costs to legitimate shipments and avoid delays, a strong digitization effort for PIC processes can significantly streamline the process, not only at points of import and export but also at every point along the reverse supply chain. Members of the Basel Convention should 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, can help bring global best practices to the PIC procedure.

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

5.3 – Move towards an insurance model for financial guarantees

Main actors:	Governments
Supporters:	International organizations, producers, recyclers, financial institutions
Pre-requisite actions:	–
Depending and interdependent actions:	**P6.6:** Incentivize technology investments for meeting future secondary material demand

If a company wants to make a shipment subject to the notification procedure, they must first put up 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 has to be accessible until the final certificate of environmentally safe repurposing is given. To avoid locking up significant amounts of capital and simplify regulatory procedures, the members of the Basel Convention should consider regulatory adjustments to 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.[21] Currently, updates on the approach for financial guarantees in the Convention are being discussed, opening a window of opportunity to move it forward.[22]

5.4 – Move to an opt-out system for transit countries and allow for flexibility

Main actors:	Governments
Supporters:	International organizations
Pre-requisite actions:	–
Depending and interdependent actions:	–

The Basel Convention requires that all transit countries give explicit consent to every transboundary shipment by undertaking the full PIC procedure. According to reporting by companies, transit countries seem to be the least likely to go through the 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: transit countries should be notified of planned shipments and have 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.[23]

5.5 – Pilot "green lanes" that ease the complexity of moving waste electronics to certified recyclers

Main actors:	Governments, producers, recyclers
Supporters:	Logistics providers, electronics manufacturers, recyclers, NGOs, regional organizations
Pre-requisite actions:	–
Depending and interdependent actions:	**P5.2:** Accelerate progress towards the digitization and simplification of the PIC procedure under the Basel Convention

Waste equipment flows tend to follow a path of least resistance. Efforts to assure that 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 "green lanes" 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 the reintroduction of materials into the circular economy. The system enabling this needs to be transparent and robust and could be created as a result of 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.

5.6 – Plan sorting, pre-processing and recycling operations at the regional and global level

Main actors:	Governments, recyclers
Supporters:	Producers
Pre-requisite actions:	–
Depending and interdependent actions:	**P5:** All actions
	P6.5: Incentivize technology investments for meeting future secondary material demand

The global reverse supply chain system for electronics could also be optimized through the 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 attract quality recycling infrastructure to emerging markets and developing countries, governments will also need to consider how to incentivize the use of certified formal recyclers and minimize the business risks associated with the illegal leakage of materials into the informal economy.

Pathway 6: Scale secondary material markets

Increasing the availability, quality and transparency on quality 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 electronics manufacturers that drive demand for secondary materials with the recyclers that supply those materials will have generate an understanding of what is needed to formalize the sector, achieve economies of scale and drive the market competitiveness of secondary materials.

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

- a lack of data standards and definitions for secondary materials,
- a lack of EHS assurance to responsible labour and environmental practices;
- a lack of transparency on the origin and content of scrap material;
- a lack of transparency on long-term supply and demand;
- a lack of investment in recycling technology; and
- a 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 the scaling of efficient and responsible secondary material markets:

P.6.1 – Develop data standards and definitions for secondary materials

Main actors:	Governments, recyclers, standards organizations
Supporters:	Producers, NGOs
Pre-requisite actions:	–
Depending and interdependent actions:	**P1.1:** Define circular electronics products and services
	P1.2: Harmonize ecolabels with respect to circularity
	P2.1: Develop guidance for circular electronics procurement
	P6.2: Create an EHS assurance scheme for secondary materials
	P6.3: Standardize material tracking and create a traceability platform

Industry-wide standards and definitions on the characteristics of secondary materials are critical for recyclers to provide the same level of assurance to material performance as virgin material suppliers. 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. Categories of focus should include material quality and quantity (i.e. volume, material type, recycled content, material composition, performance, purity), chain of custody (i.e. origin, destination, previous owners, facility, country) and production characteristics (EHS practices, recycling processes, material handling, workers' safety, environmental management systems). The taskforces will identify necessary data elements based on gaps in existing standards and definitions and collaboration with related standard-setting efforts (e.g. EU CEWASTE[24]), create alignment on data and definitions and provide standardized reporting guidelines for secondary materials.

P6.2 – Create an EHS assurance scheme for secondary materials

Main actors:	Industry associations (recycling, manufacturing), international organizations, NGOs, workers' associations
Supporters:	Standards organizations
Pre-requisite actions:	**P3.9:** Enforce labor rights and enable the formalization of companies and workers
	P6.1: Develop data standards and definitions for secondary materials
Depending and interdependent actions:	**P2:** Commit to meeting the demand for circular products and services

The current lack of EHS assurance makes the purchasing of secondary materials an unacceptable business risk for many electronics manufacturers, as it undercuts their due diligence processes in other parts of the value chain. This curbs demand growth and slows down the integration of more recycled content into new electronic products. Building off the standardized reporting guidelines from the prior action, industry associations, international organizations (such as the UN), NGOs and workers' organizations can define industry-wide standard and criteria for determining the EHS performance of secondary material producers. The objective should be to drive consistency in EHS expectations for the recycling sector, especially in relation to engagement with the informal sector, and create more demand for secondary materials. The long-term target 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 materials (see Pathways 4.4 and 5.1)

P6.3 – Standardize material tracking and create a traceability platform

Main actors:	Electronics manufacturers, recyclers, materials suppliers
Supporters:	Standards organizations, technology developers
Pre-requisite actions:	**P6.1:** Develop data standards and definitions for secondary materials
Depending and interdependent actions:	**P3.4:** Invest in circular business models with social and environmental impact
	P4.8: Tie take-back and collection to the business model

Standardized material tracking and traceability can help to ultimately overcome the lack of information about origin and routes of recovered materials and further 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 to 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 development of a traceability platform to collaboratively define necessary data (e.g. chain of custody, origin, volume, quality, EHS standards), identify data sources, transferability and confidentiality and align on reporting mechanisms and processes. The technology or data platform to support traceability can be developed over time, evolving from targeted surveys into a publicly available, automated platform that serves as an ongoing reporting mechanism.

P6.4 – Increase transparency on secondary material demand and supply

Main actors:	Governments, recyclers
Supporters:	Producers
Pre-requisite actions:	**P6.1:** Develop data standards and definitions for secondary materials
Depending and interdependent actions:	**P1.3:** Develop and roll out an education program for circular electronics design
	P6.5: Incentivize technology investments for meeting future secondary material demand

Improving transparency on secondary material demand for recyclers and secondary material supply for sourcing professionals can inspire supply creation and investment and facilitate manufacturers' long-term procurement decisions for secondary materials. Industry associations or NGOs can create space for designers from electronics manufacturers and recyclers to focus on overcoming technical barriers related to the use of secondary materials and increase transparency on current and future demand for materials (especially scarce and rare earth metals, mass metals, plastics). They can develop a platform for recyclers and manufacturers to share available supply and demand forecasts, creating an aggregated market signal capable of driving market forces in the right direction.

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

Main actors:	Governments, recyclers
Supporters:	Producers
Pre-requisite actions:	**P6.4:** Increase transparency on secondary material demand and supply
Depending and interdependent actions:	**P2.4:** Commit to meeting the demand for circular products and services
	P5: All actions [reverse logistics enables economies of scale in recycling]

Unstable scrap material flows (see Pathway 5), decreasing precious metal contents, increasing material complexity and the significant costs of compliance and de-pollution all limit the financial viability of recycling operations and incentives for investment in new technologies and infrastructure. To ensure that future demand for secondary materials can be met, governments and financial institutions should create financial support mechanisms 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 the demand for recycling is driven by the 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 the undercutting of market prices by non-compliant actors.

P6.6 – Incentivize the sale of secondary materials

Main actors:	Governments, recyclers
Supporters:	Producers
Pre-requisite actions:	–
Depending and interdependent actions:	**P2.4:** Commit to meeting the demand for circular products and services

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 to secondary material production. This is especially relevant where, through complexity in value chains (e.g. regulatory processes related to reverse logistics, see Pathway 5) or lower economies of scale, that of secondary materials exceeds that of virgin materials. Downstream incentives for circular products should be combined with upstream incentives for circular materials and supported by policies to increase the sale of recycled materials (e.g. tax reductions, subsidies) during the circularity transition.

Measuring Progress

The CEP is an action-oriented initiative seeking ways to measure the progress towards a fully circular electronics industry.

For each of the actions in the Roadmap and each segment in the value chain, individual key performance metrics can be built to measure progress against self-defined objectives. Beyond this necessary and granular approach, how could circularity progress be measured at an aggregated level?

In the last few years, the private sector has made significant progress in developing metrics to measure circular performance. Among them, World Business Council for Sustainable Development's (WBCSD) Circular Transition Indicators v2.0[25] (CTI) is a simple, objective and quantitative framework that can be applied at the company, business unit, facility or product (group) level. Companies in the electronics industry are already measuring the circular performance of their products using CTI.[26]

At the level of the global electronics industry, at least for the broader public, the focus is a single metric: the amount of e-waste generated, as defined in the Global E-waste Monitor published by UNU/UNITAR, ITU and ISWA.[27] We argue that the perspective needs to change to perceive the material as post-consumer resources and with key measures for monitoring focusing on the amount of end-of-life or end-of-use electronics that have been given a new life (as product or as materials). Further measures across different areas need to be considered to measure the *progress* of the industry towards circularity. On top of the question of social performance, the CEP suggests refining the metrics specific to the electronics industry (shown opposite). To make progress transparent, the following metrics need to be publicly available:

Product and services market

Products and services:

- % circularity of product portfolio
- % of annual revenues coming from circular products and services
- % change in annual revenue divided by linear resource consumption over time (decoupling)

Material sourcing:

- % of companies that have modified their sourcing programs to include commitment to circularity (linked to secondary material market)
- % of resources used in manufacturing a product that qualify as "circular"

Procurement of equipment:

- % of total yearly public and private sector electronics (e.g. IT) category spend that includes a preference for circular products and services (note: for the public sector, reporting can be at national, municipality and city levels)

Collection and recycling:

- % of formally documented collection and recycling (as defined by the Global E-waste Monitor)

Collaboration:

- # of companies and organizations in CEP
- % market cap of electronics companies engaged in CEP

Secondary material markets

Functioning markets:

- Quality/specs of secondary raw materials versus its virgin or primary counterparts
- Growth in recycling economy: market volume, material production, jobs, etc.
- Investment in recycling industry
- Efficiency rate measured by recovery rate of input materials (indicates environmental impact and the value of materials)

Secondary material use:

- % of materials sourced from secondary materials in the electronics industry

Conclusion

Our Roadmap highlights 40 actions. They have been carefully designed and selected over months of intensive dialogue between more than 80 experts from companies and NGOs.

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

While the roadmap of actions is structured around six Pathways, no action can be achieved by a single category of players: cooperation of value chain players with other stakeholders such as public authorities, research organizations and academia, financial institutions, social enterprises, media and consumers will be key to executing the proposed roadmap and sharing experiences. For this, 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 the best practice into policy will require action by public authorities.

Creating a shared understanding and clear definitions is key for other actions

The concept of circular economy is not new. But defining a circular electronic product or service is a new frontier. Establishing a common language will facilitate increased cooperation between value chain partners and key stakeholders. Like in 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 existing processes will also support the transition

Improving PIC procedures from the Basel Convention, rolling-out EPR schemes to new countries and reporting on the financial performance of circular business models are all actions where the improvement and scaling of existing solutions and processes can drive progress towards more responsible circularity.

Private-public cooperation is key to achieving scale

Changing the as-is system requires publicly financed incentives, such as incentives for private investment in waste processing capacities or for secondary material procurement. Without public support, a "coalition of 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 such as 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 harmonization of extended producer responsibilities globally.

Circular electronics create value for the industry, its customers and society

The tech industry is uniquely positioned to raise awareness of the concept of circularity and make it tangible for people around the globe. Nearly all people are connected to an ICT device – this reflects the opportunity but also the responsibility that the IT sector faces. It can significantly contribute to the UN SDGs and enhance people's lives but needs to ensure responsible action along the whole value chain. Incorporating circular thinking and value into the products and services of the electronics industry allows companies to responsibly meet the growing prominence of technology, while enabling society to remain resilient and innovative, and become more sustainable.

This Roadmap is the first step towards supporting the industry to identify the concrete actions needed to achieve circularity. The CEP will strengthen collaboration among key stakeholders to realize the vision behind each identified Pathway.

Annex

Glossary

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.
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 product design	Incorporating elements in the design stage of a product, aiming to enable 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]
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 Partnership (CEP)	An industry coalition and author of this paper. See the introduction for further details.
Circular products and services	Products and services that deliver environmental benefits through incorporating elements of the circular economy. [definition to be specified further, see intervention plan]
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.
Electrical and electronic equipment (EEE)	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.
Circular electronics	See circular products and services.
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 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]
Electronics manufacturer	A business manufacturing EEE, including original equipment manufacturers. Manufacturers can also be producers if they sell or lease directly to consumers.

Informal economy	Informal system that operates without clear regulation or quality control and outside the guidelines of governmental authority, labor standards or taxation.
Producer	Anyone who places 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 in to 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 viable option.
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 which are dispossessed by the consumer are collected and moved to a place where they can be efficiently and safely reused or recycled.
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.
Sourcing	Procurement of products, components or raw materials (whether virgin or secondary materials).
Take-back	This involves B2C, B2B and B2G take-back of EEE that has reached the end of its primary life or cycle in its original form, is incapable of performing its original intended function or is no longer required by its purchaser or user. The purpose of take-back is to maintain the life cycle value of EEE through reuse, repair, reprocessing, remanufacture 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 EEE).

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